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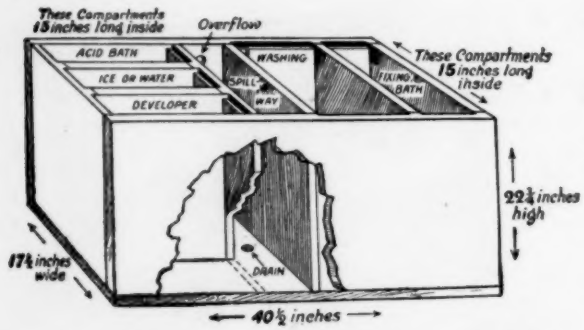

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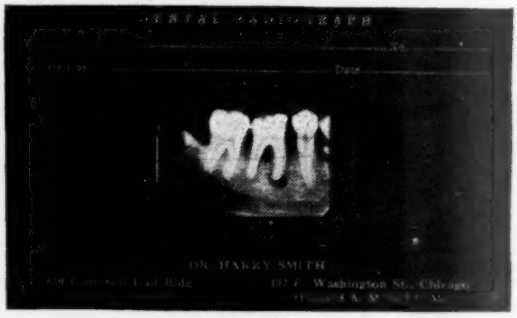

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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VOL. VII (NEW SERIES) FEBRUARY, 1920 No. 2

THE AVIATOR'S HEART. ROENTGEN RAY STUDIES UNDER CONDITIONS SIMULATING HIGH ALTITUDES*

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NEW YORK CITY

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Chief of the Cardiovascular Department, Research Laboratory, Air Service

MINEOLA, L. I.

DURING the examination of aviators under reduced atmospheric pressure (Fig. 1) in the low-pressure chamber at the Medical Research Laboratory at Mineola, N. Y., Major James L. Whitney, M. C.,[1] and his co-workers had observed at pressures corresponding to altitudes of 18,000 or 20,000 feet an increase in the area of cardiac dullness in the case of certain aviators. Later, a similar increase in the cardiac dullness was occasionally observed during the course of the low oxygen test, conducted at the laboratory for the purpose of classifying aviators according to their ability to withstand the effects of high altitudes. The enlargement as observed by Whitney was principally to the left, but occasionally right-sided enlargement was encountered in addition (Fig. 2). Whitney ascribed the increased area of dullness in these cases to dilatation of the heart, and thought that it was due partly to fatigue, such as occurs after excessive exertion, as in Marathon runners, and partly to lowered tonus of the heart muscle arising from the lessened oxygen content of the inspired air and of the blood.

The present studies were undertaken to determine whether cardiac enlargement actually does occur under these circumstances; and if it does, what is its amount; whether its onset is sudden or gradual; what is its relation to the blood pressure and to the psychomotor reactions of the aviator; and whether it is a conservative process designed to increase the output of blood by the heart, or whether it is a true dilatation due to fatigue or exhaustion of the heart muscle.

Two series of studies were planned; one with the Henderson rebreather, and the other in the low pressure chamber. The rebreathing experiments were undertaken first, because any changes observed would almost surely be due to diminished oxygen alone; whereas, in the low pressure chamber they might be influenced by the change in pressure or by the expansion of abdominal gases causing an upward displacement of the diaphragm.

The Henderson rebreather (Figs. 3 and

[1] "Medical Studies in Aviation," *J. Am. M. Assn.*, Oct. 26, 1918.

*Read at the Twentieth Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Saratoga Springs, N. Y., September 3-6, 1919; at the Medical Section, N. Y. Academy of Medicine, June, 1919, and also in abstract at the American Association for Thoracic Surgery, June 9, 1919.

4) consists of an iron tank of about 60 to 100 litres' capacity, provided at the top with a water-sealed spirometer, and connected through tubing with a mouth-piece through which the subject breathes. The nose is clamped with a spring "clothes-pin," so as to close the nostrils tightly. An arrangement of two mica check-valves causes the inspired air to flow through one tube, and the expired air to flow through the other back into the tank. The expiratory tube has inserted in its course a cartridge containing "shell" potassium hydroxide to absorb the exhaled carbon dioxide. As the subject of the experiment breathes the air in this tank over and over, he gradually uses up the oxygen until finally he may come to a point where he is breathing an oxygen-nitrogen mixture containing only 8, 6 or even 5 per cent of oxygen instead of the usual 21 per cent in normal air. Since the nitrogen is bland and neutral (simply a vehicle, as it were, for the administration of oxygen) the effect of diminishing the percentage of oxygen in the rebreather has the same physiological effect as rarefying the air in a low-pressure chamber, or ascending to a high altitude. In either case, the actual amount of oxygen available for the blood in a given four litres of lung capacity becomes progressively less as the experiment proceeds or as higher altitudes are reached.

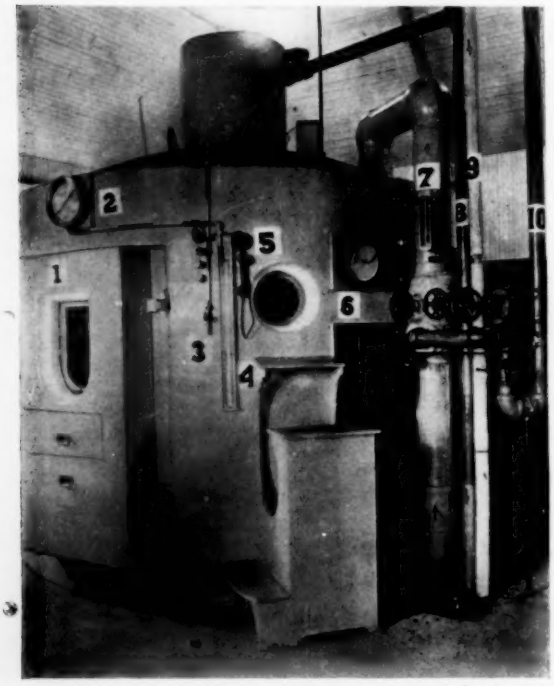


FIG. 1. LOW PRESSURE TANK USED IN STUDY OF THE AVIATOR'S HEART.

In our first series of observations, roentgenograms were made of aviators every five minutes while they were in the rebreathing apparatus. The length of the run on the rebreather varied from fifteen minutes to thirty-eight minutes. With the controls taken before and after the run, there were obtained from six to thirteen roentgenograms of each heart.

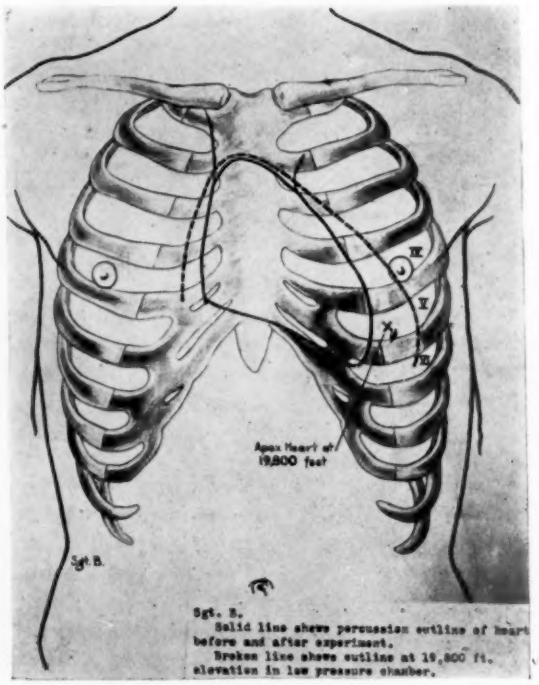

Apex Heart at 19,800 feet
Sgt. B.
Sgt. B.
Solid line shows percussion outline of heart before and after experiment.
Broken line shows outline at 19,800 ft. elevation in low pressure chamber.

FIG. 2. CARDIAC ENLARGEMENT TO BOTH RIGHT AND LEFT AS DETERMINED BY PERCUSSION IN THE LOW PRESSURE CHAMBER. (WHITNEY.)

The greatest care was taken in the alignment of the tube, the patient, and the plate, so as to make the radiographs properly comparable one with another, not only those of the same, but also those of different subjects. The sitting posture offered the most advantages, as not interfering with the rebreathing apparatus, and also as enabling the sub-

jects to maintain a fixed position for the required length of time. In order to make sure that the alignment was maintained throughout the experiment, a special chair was built having a straight back containing a large transparent celluloid panel. Down the center of the back a perpendicular line

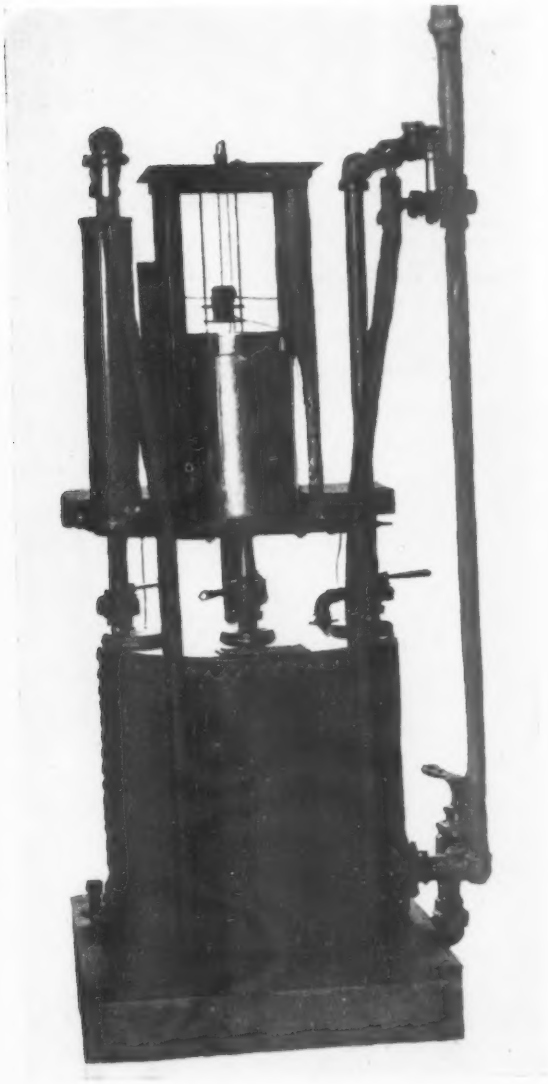
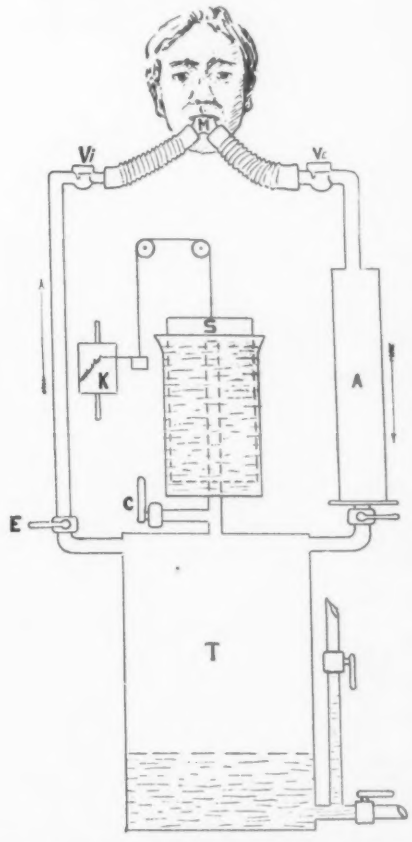


FIG. 3. THE HENDERSON REBREATHER.



The rebreathing apparatus employed in all routine tests of the aviators' ability to withstand low oxygen. It consists of a tank, *T*, of about 120 liters capacity. The volume of air is determined by the amount of water that is run into it. The man under examination continually rebreathes the air of the tank (a clip is placed on his nose) through the inspiratory and expiratory valves, *Vi* and *Ve*. The oxygen is thus consumed and reduced. The exhaled carbon dioxid is taken up by sodium hydroxid in the absorber, *A*. The movements of respiration are recorded by the spirometer, *S*, connected to a smoked drum, *K*. As the oxygen is consumed and the air volume is thus reduced, the spirometer falls and the graphic record on the smoked drum rises. At the end of the test a sample of air is drawn from the tank and analyzed as a confirmation of the oxygen consumption and of the oxygen percentages (that is, altitudes) indicated by the graphic record.

FIG. 4. DIAGRAM OF THE HENDERSON REBREATHER.

of position and of recording it on the plate, if it occurred, a distinctive metal marker was placed on a given posterior spinous process, and another upon the sternum. After several trials, a small metal washer of about ½ inch diameter, fixed by adhesive plaster over the spinous process of the 7th dorsal, was drawn and divided off into inches to indicate the distance above the floor, so that the target of the *x*-ray tube could readily be adjusted to any required height to correspond with the point selected on the back of the subject. As a means of detecting change and a straight lead rod, 2 or 3 inches long, down the center of the sternum, were found to be very satisfactory. The displacement of their shadows laterally, or upward or downward, served to indicate the slightest change in the alignment and in the posture of the

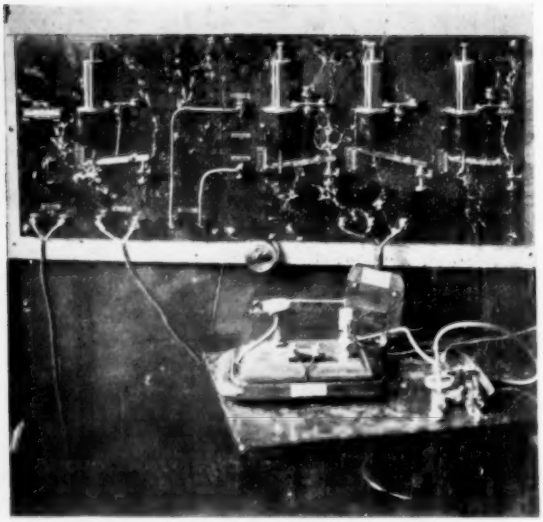


FIG. 5. TIMER TO SET OFF THE X-RAY EXPOSURE IN RELATIONSHIP TO THE PULSE. Specially devised switch activated by the pulse seen in foreground.

subject. In a few studies of the movements of the diaphragm, each nipple was marked with a small lead circle, and the apex by a cross.

Teleroentgenograms were made at a 2 m. distance and were taken during both inspiration and expiration. Serial radiograms were made at a 75 cm. distance in both expiration and inspiration, and in certain instances double exposures on one plate were made to show both inspiration and expiration. The shorter distance was adopted for convenience as being the least possible for working through the aluminum window of the low pressure chamber. In view of the danger of implosion, this window was made of pure aluminum 15 mm. in thickness. (Figs. 7 and 8.)

The exposures varied from 1/20 to 3/20 of a second at the 75 cm. distance, and from 1/10 to 3/5 of a second at the 2 m. distance. In the series on the rebreather the double exposures were most successfully obtained with that in expiration given 3/20 of a second, and that in inspiration given 1/15 of a second. Short and practically instantaneous exposures were necessary during the rebreathing tests, because it is impracticable to have the subject hold his breath at the lower oxygen percentages. Holding the breath under these circumstances is liable to produce dizziness and fainting, or other symptoms of oxygen want in the brain.

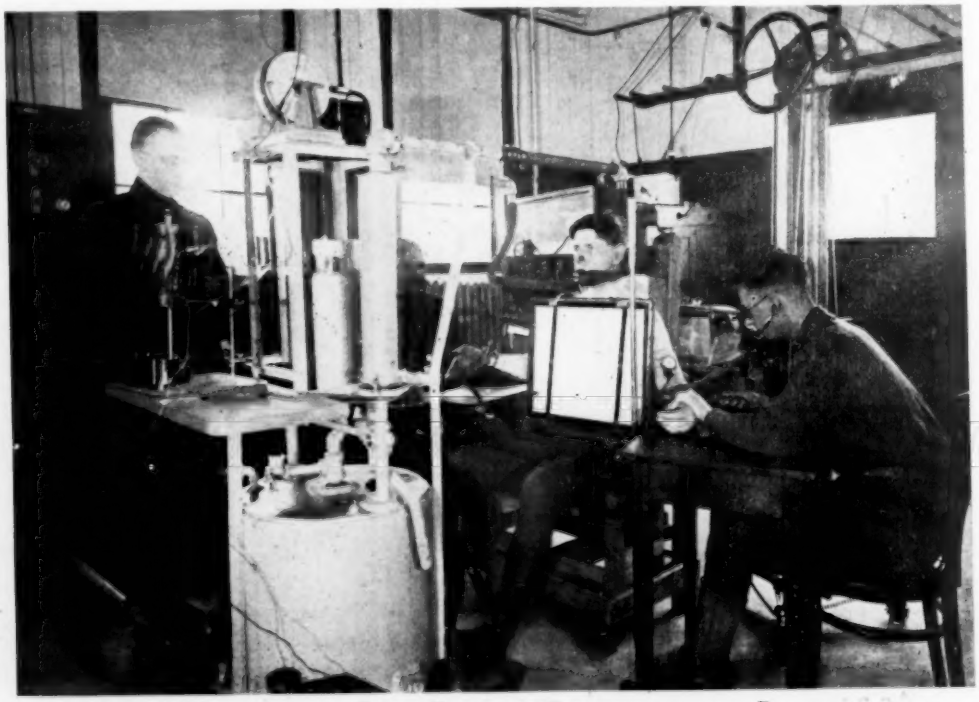


FIG. 6. ROENTGENOGRAM BEING TAKEN IN CONJUNCTION WITH REBREATHER, ETC.

In the low pressure chamber, exposures were made through the aluminum window at the 75 cm. distance in 3/20 of a second. Single rapid intensifying screens were used in all exposures. The exposures were made on *x*-ray plates of standard makes issued by the army. The plates were developed by the tank method, with Eastman *x*-ray developer. The transformer was one of the Base Hospital types issued by the army. The exposures were timed by a special timer, depending upon the principle of falling weights, its correctness having been checked by stop-watch and metronome. Because of the shortness of the exposures, it was thought necessary to time them for a definite period of the cardiac cycle, in order to avoid possible variations in size due to systole and diastole. The timer was therefore actuated by a special mechanism set off by the pulse wave (Fig. 5). This was merely an adaptation of the wrist piece and tambour of the Mackenzie polygraph, with the writing arm equipped with a platinum end that dipped into a mercury cup to close the electric circuit which actuated the timer. The timer could be set to make the exposure with the pulse beat or at definite fractions of a second after the pulse (Fig. 17). In our serial plates with the rebreather, the exposures were timed to be synchronous with the diastolic phase of the heart cycle.

FIG. 7. ROENTGENOGRAM BEING TAKEN IN THE LOW PRESSURE CHAMBER THROUGH THE 15 MM. ALUMINUM WINDOW.

A record of the respiratory phase of the exposure was made by means of a perforation of the kymograph tracing by a high

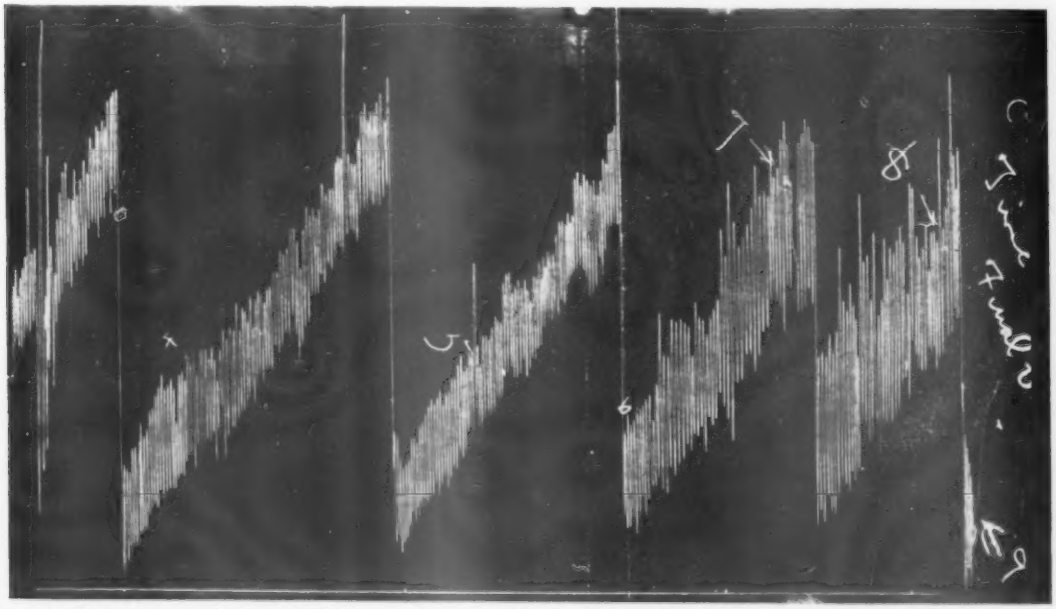


FIG. 8. KYMOGRAPH TRACING. CASE 142. Note at the beginning the irregularity of the respiratory curve (psychic), and toward the end the greatly increased depth due to oxygen want.

tension spark. This spark was obtained by shunting off through resistance a small amount of current from the primary terminals of the *x*-ray transformer, and then stepping it up to a high tension and passing it through a small Leyden jar as a condenser. (Figs. 6 and 8.)

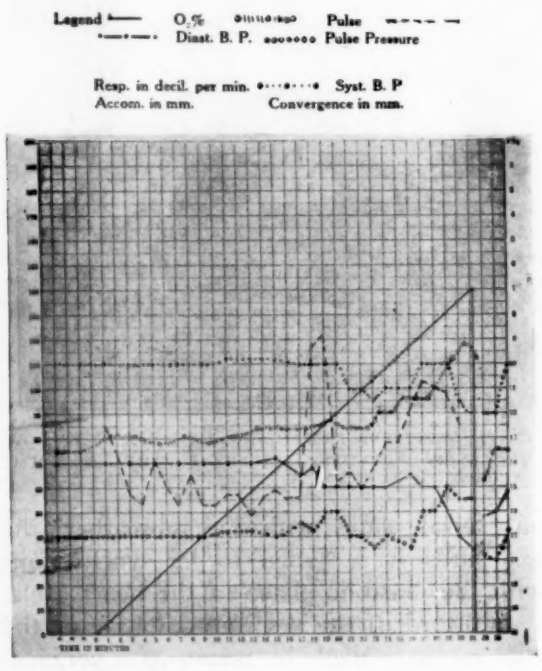


FIG. 9. CASE 142. CHART SHOWING CIRCULATORY FAILURE. MODERATE RESPIRATORY EMBARRASSMENT.

The pulse rate, systolic and diastolic blood pressures, were taken every other minute until the fifteenth minute, after which time they were taken every minute. A record of the volume of air inspired per minute was also kept. (Fig. 9.) All of our subjects were healthy aviators, ranging in age between twenty and forty-two years.

In the very beginning of our work it became evident that different silhouettes of the same heart varied greatly in form and in measurement of the transverse diameter (Fig. 17). As the tube distance, position of the subject, and the alignment remained the same, it was evident that the cause was some change taking place in the subject himself. After a series of radiographs it appeared that the preliminary controls taken during forced held inspiration showed a narrower heart than any of those taken during the course of the rebreathing tests. We then took an extra plate during forced held expiration, and found that these gave a broader shadow than those taken during the course of the rebreathing.

By superimposing a silhouette taken in *expiration* upon one from the same subject taken in *inspiration* (Figs. 11 and 12), so that the shadows of the metallic markers upon the backs coincided and the shadows of the vertical rods on the sternum were parallel, the changes taking place in the shape and position of the heart during deep respiration could be readily seen. It should be borne in mind that every exposure in each series was made during the same phase of the cardiac cycle. This was usually one-fifth of a second after the pulse wave arrived at the wrist, but some were set off at the moment of the pulse beat. In either case it is presumed that the heart outline is that of diastole.

By this method of superimposing plates the excursion of the diaphragm upward in *expiration* was readily demonstrated, and the simultaneous lowering of the apex of the thoracic cavity was indicated by the lower position of the clavicles and of the sternal marker. This was only a different way of demonstrating facts already well known; but the changes in the mediastinal contents

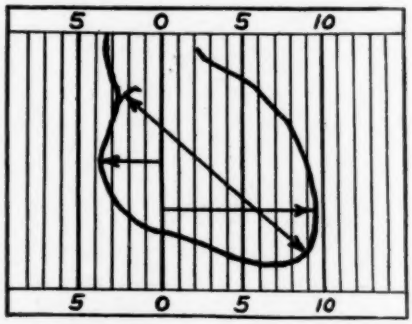


FIG. 10. USE OF TRANSPARENT SCALE FOR QUICK MEASUREMENT OF THE SIZE OF HEART SHADOW. The transverse diameter is instantly read off as 13.25 cm.

were to us rather surprising. This method was supplemented and the results verified by making two exposures of the same subject on one plate (Figs. 13 and 14).

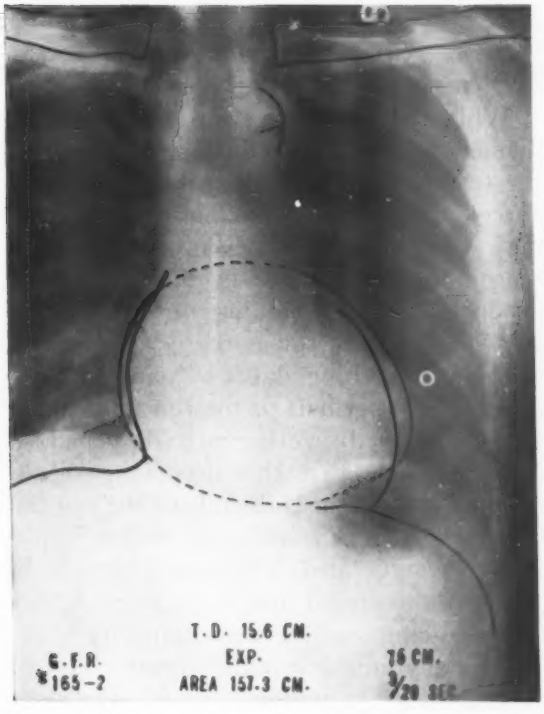


FIG. 11. HEART IN INSPIRATION AND IN EXPIRATION OUTLINED AFTER THE METHOD OF BARDEEN AND THE PLATES THEN SUPERIMPOSED. Change of Position of the Heart and Increased Prominence of Position of the Aorta Indicated. Position of the Clavicles during Inspiration Outlined.

The lifting of the apex and the broadening of the transverse diameter of the heart during expiration have been recognized by amount of this change does not seem to have been fully realized. Furthermore, most authorities speak only of left-sided displacement and apparent enlargement; whereas our results show in many cases decided broadening of the heart shadow toward the right as well as toward the left. The result is a marked increase in the transverse diameter. In several cases this increase amounted to over 3 cm. If radiographs should happen to be taken of the same heart at different times and in different phases of respiration, such differences in the transverse diameter of the shadow might easily be misleading and be the cause of a mistaken diagnosis of enlargement of the heart.

Our results would seem to show that during normal quiet respiration the changes in the transverse diameter are comparatively small, notwithstanding a fairly large excursion of the diaphragm (Fig. 13). We would explain this by the fact that the chief movement of the diaphragm in quiet breathing is in the two domes on each side of the central tendon, while the tendinous portion under the heart itself remains comparatively quiescent. Moreover, the slant of the portion of the diaphragm beneath the heart downward and forward is little changed in ordinary breathing. But in forced breathing the sulcus formed between the diaphragm and the anterior chest wall, which is partly filled by the lower border of the heart is obliterated during inspiration by the flattening of the whole diaphragm. During expiration the sterno-phrenic sulcus is rendered so sharp and thin by the rounding up of the diaphragm that the heart is squeezed upward. Conversely, the apex of the thorax and of the mediastinal space is lowered with the fall of the ribs and sternum in expiration, and raised in inspiration.

The resulting approximation of the apex and base of the mediastinal space during *expiration* thus tends to squeeze the contained organs outward and to broaden their

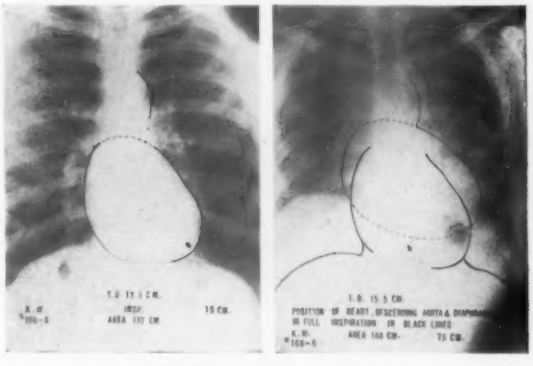


FIG. 12. AT LEFT OUTLINE OF HEART, AORTA AND DIAPHRAGM DURING INSPIRATION. AT RIGHT OUTLINES IN EXPIRATION, WITH THE INSPIRATORY POSITION SUPERIMPOSED AND DRAWN IN BLACK. Position of the clavicles in inspiration also drawn in black. The outline of the lead markers by means of which the plates were centered, are not shown in these reproductions.

shadows. The lengthening of the thoracic cavity during *inspiration* tends to stretch out the contained organs and to narrow their shadows. That this is no mere theory but does actually occur is shown by the increase

during expiration of the transverse measurements of the mediastinal silhouette at all levels. As in the case of the heart, it is also shown by making two exposures of the thorax on the same plate, one during expiration and one during inspiration. (Fig.

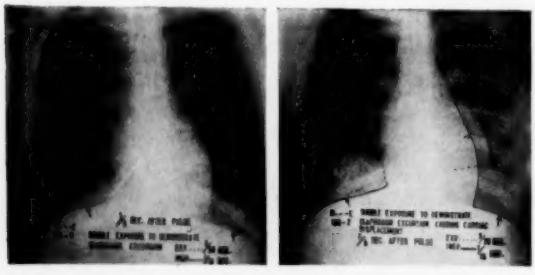


FIG. 13. TWO EXPOSURES ON ONE PLATE. MODERATE EXCURSION OF THE DIAPHRAGM (LEFT HAND PLATE.) PRODUCES SLIGHT BROADENING OF THE TRANSVERSE DIAMETER: A GREATER EXCURSION CAUSES INCREASE IN THE TRANSVERSE DIAMETER (RIGHT HAND PLATE).

14.) The apparent broadening of the aortic arch, especially its displacement to the left, is very noticeable in such plates. Two radiographs, such as those shown in Fig. 14, diameters in forced inspiration and forced expiration in atmospheric air was 3.3 cm. at if taken several months or years apart might

man was 3.5 cm., and the smallest variation was 0.15 cm. The average difference was 0.47 cm. at 75 cm. distance.

While the variations in the transverse diameter of the heart during the rebreathing test averaged less than those caused by forced inspiration and expiration, yet they may occasionally be even greater. The reason for this is that the rebreathing test produces forced breathing in certain aviators. In the early stages there is frequently irregular breathing due to excitement, but during the latter half of the run the respiration is normally very much deepened. It seems possible that this deepening results from an increase at both ends of the respiratory movement. Expiration as well as inspiration is exaggerated. This would seem to be shown in many of the respiratory kymograph tracings, where the expiratory curve occasionally goes below the average level of the expiratory excursion (Fig. 8). The same changes in the respiratory movement occur in the low pressure chamber or during an ascent to a high altitude as in the rebreathing test. There is an increase in the volume of air breathed per minute, and this increase

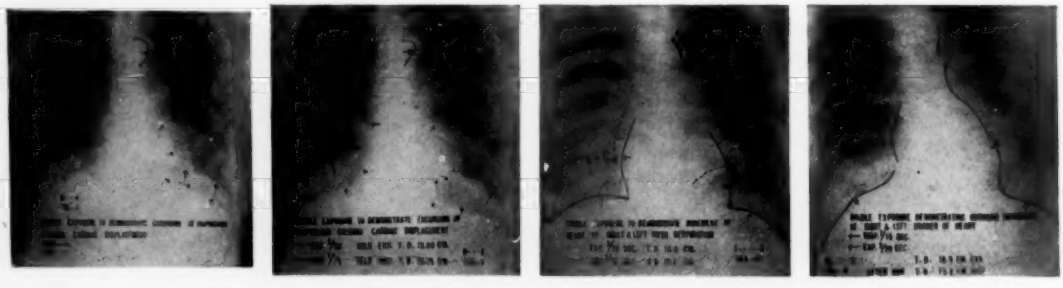


FIG. 14. EXAMPLES SHOWING TWO EXPOSURES ON ONE PLATE TO DEMONSTRATE RESPIRATORY DISPLACEMENT OF THE HEART DURING DEEP BREATHING.

easily lead to a serious mistake in diagnosis.

Out of a series of plates of 89 men, the largest difference between the transverse 75 cm. distance. The average variation was 1.37 cm. One heart showed no change in the transverse diameter—a case of valvular disease measuring 17.5 cm. at 2 metre distance.

During the course of the rebreathing tests of the same 89 aviators, the greatest variation in the transverse diameter in any one

in the minute volume results from deep breathing much more than from an accelerated rate.

Practically we found it extremely difficult, or even impossible in many cases, to time our exposures with any desired phase of respiration. Watching the kymograph drum one frequently would snap the switch at what one thought was the height of inspiration, and the next pulse beat would set off the exposure; but the subject would go on

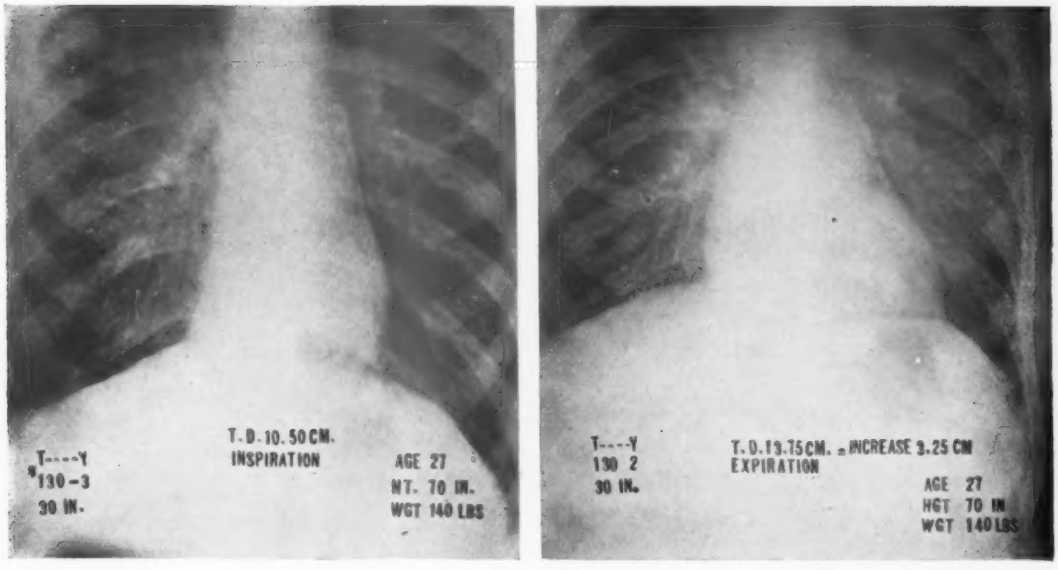


FIG. 15. THE SAME HEART IN INSPIRATION AND IN EXPIRATION. CHANGE IN TRANSVERSE DIAMETER 3.25

taking a long breath, and we would really have a radiograph taken in mid-phase respiration; or sometimes the electric connection would not be made in the mercury cup until the expiratory movement had begun, or even been completed. Such irregularities in the depth of respiration are indicated in the kymograph tracings of cases 110, 142, 116, shown in Fig. 8. The clinician in palpating and percussing the præcordium will detect the upward and outward position of the left border during expiration, and will probably fail to notice its return downward and inward during inspiration. A diagnosis of cardiac enlargement would be obvious and natural under such circumstances. It seemed to us that this might be the explanation of Whitney's findings (Fig. 2). The similarity of his drawings of the heart outlines, as obtained by percussion, and those obtained by us by two exposures on the same plate is very striking. (Figs. 13 and 14.) It therefore seemed essential that the respiratory phase should be taken into account in our study of heart measurements.

In the low-pressure chamber, the expansion of the intra-abdominal gases which accompanies reduction of the external pressure, is frequently very troublesome both to the subject and to the observer. It would tend to increase the upward move-

FIG. 16. INSPIRATION HELD 138 SECONDS. Note changes in the outline of the heart and position of the diaphragm, indicating the variation which may be obtained in the heart outlines during prolonged holding of the breath.

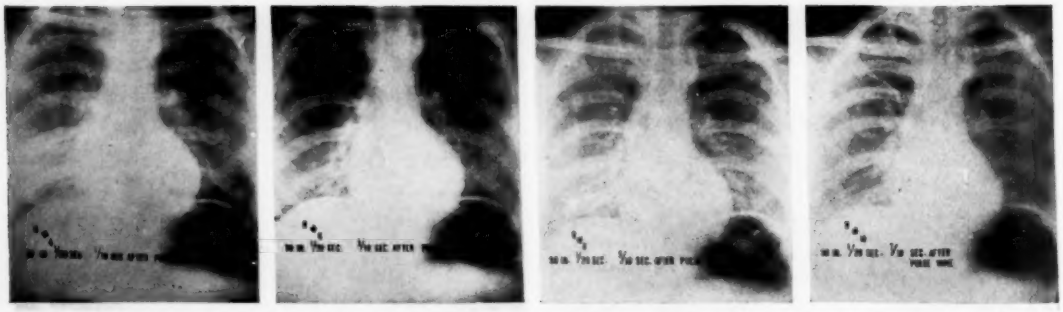


FIG. 17. HEART CYCLE WITH ALTERNATE EXPOSURES MADE AT INTERVALS OF 1/10 SEC. AFTER PULSE WAVE. Exposure time 1/20 sec. Target Distance 75 cm.

ment of the diaphragm in expiration, and to exaggerate the cardiac displacement. We should therefore expect to have an increase in the transverse diameter of the heart occur more frequently in the low-pressure chamber than with the rebreather.

Turning again to the heart shadows of the 89 aviators, we can readily divide them into three classes. The first class includes 66 subjects and comprises those in which no enlargement of the heart occurred under lowered oxygen pressures. While marked variations in the transverse diameter in the different plates occurred in a considerable proportion of these men, the changes were distributed so irregularly throughout the run, that they could not be attributed to oxygen want or to the progress of the test. In no case was the enlargement at the end of the run. (Fig. 19.)

The second class includes 9 cases which showed a more or less consistent increase in the transverse diameter toward the end of the test (Fig. 20). The greatest increase was 1.4 cm., and the least 0.2 cm. The average change was 0.75 cm. Careful study of the position of the diaphragm and of the respiratory phase at which the plate was exposed showed at once that in six of these cases the enlargement was merely expiratory displacement. For example, in case 152 the increase of the transverse diameter of the

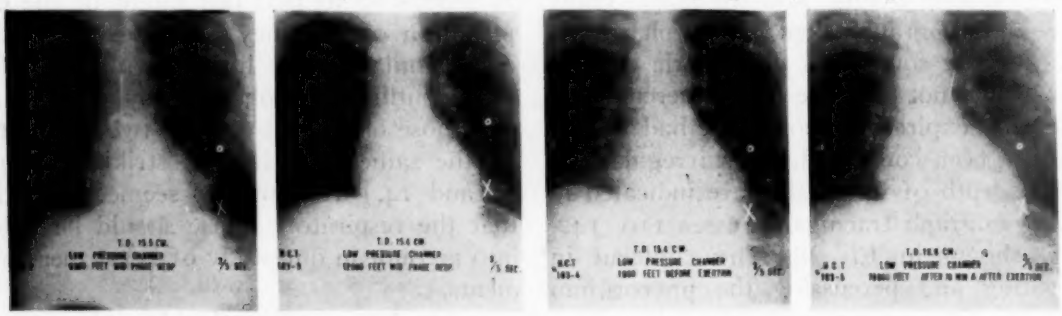


FIG. 18. HEART OUTLINES TAKEN IN THE LOW PRESSURE CHAMBER. Note the apparent enlargement after exercise at a pressure corresponding to 18,000 feet.

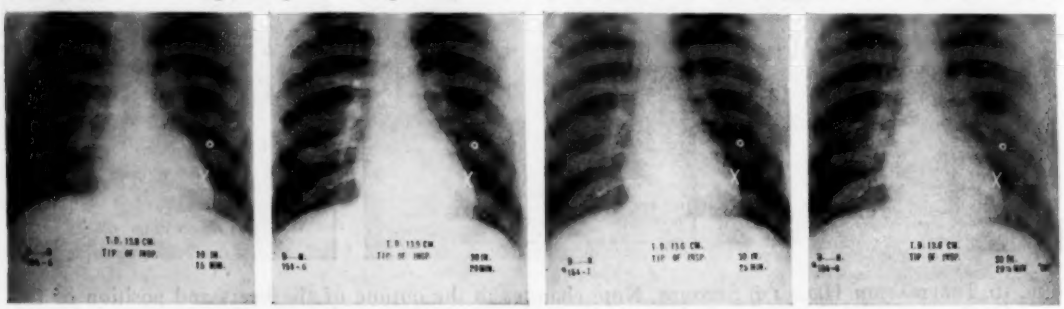


FIG. 19. SERIES OF THE HEART DURING REBREATHING TEST. All obtained at the tip of inspiration and showing no change in the transverse diameter.

heart silhouette was 1.25 cm. At the time of this increase the shadow of the diaphragm had moved upward a distance of 4.5 cm. from its position in the preceding plates. That is, it had moved from 7 cm. below the left nipple and 5 cm. below the right nipple (its position in inspiration) to 2.5 and 1.5 cm. from the respective nipples.

Again, in Case 37, the 1 cm. increase occurred at the twenty-fifth minute of the run, at the time of psychomotor inefficiency when the subject was sitting rigid in the chair. The radiograph shows the diaphragm in the position of expiration. The blood pressures were practically unchanged. The systolic ranged between 110 and 120, with the terminal at 112. The diastolic varied between 64 and 72, the final reading being 64. The pulse rate was not unduly accelerated. In short, there were no evidences of heart strain. We do not believe the diagnosis of dilatation justified in these two cases. Similarly the enlargement of the transverse diameter in cases 21, 32, 40 and 77, is explainable by variations in the respiratory phase at the moment the exposures were made.

In the other three cases, the increase was 0.4 cm. or under, and is not explained by the expiratory position of the diaphragm. In cases 90 and 185, the increase is only 0.2 cm. and was regular and progressive from start to finish. The systolic pressure in Case 125 increased during the rebreathing test from about 130 to 144 mm., while the diastolic dropped from 70 to 40 mm. The pulse pressure ranged from 60 in the beginning to 104 at the end. The pulse rate increased from 90 to 112. The subject at the end was still conscious but showed muscular twitching and motor inefficiency.

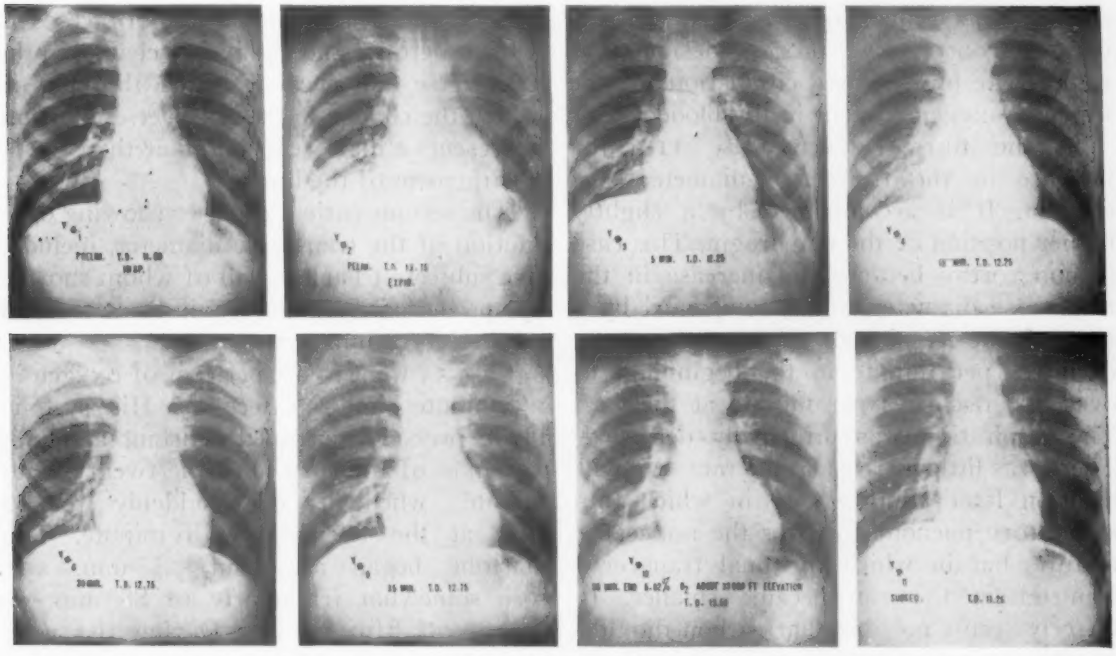


FIG. 20. APPARENT ENLARGEMENT OF THE HEART DURING REBREATHING TEST. The heart outline at 38 minutes (oxygen diminshed to an extent corresponding to an altitude of about 33,000 feet) shows a transverse diameter of 13.50 cm. with the diaphragm at a somewhat higher level than in any of the preceeding exposures during the run.

Case 90 shows a slight increase in pulse pressure at the end of the run (from 35 to 49 mm. Hg.). The pulse rate accelerated from 90 in the beginning to 117 at the end.

It is possible that the increased transverse diameters in these two cases represent actual enlargement of the heart. If such is the case, it could possibly be explained by the diminished tenus of the cardiac muscle brought

about by oxygen want. This would perhaps account for the greatly increased pulse pressure, which was produced partly by increased output of blood at each cardiac systole, and partly by the increase in the rate of the beat. The final result would be a greatly increased output of blood per minute. Since the increased pulse pressure in both cases is due to lowering of the diastolic pressure together with a slight increase in the systolic pressure without any other sign of heart strain, we are inclined to consider such an enlargement of the heart, if it occurs, a conservative process designed to compensate by increased circulation for the lessened oxygen content in the blood.

In the third subject, Case 110, the increase in the transverse diameter was 0.4 cm. It is accompanied by a slightly higher position of the diaphragm. This case is noteworthy because the increase in the transverse diameter was accompanied by a rise of the respiratory volume from 65 decilitres per minute in the beginning, to over 200 decilitres per minute at the end. The respiration was principally deepened. There was little increase in the rate. We will mention later another case in which this respiratory phenomenon was the noticeable feature, but in which the final transverse diameter in the run became smaller. It scarcely seems possible that carbon dioxide retention of elimination can explain these two opposite reactions.

The third class of cases includes those in which there was a *decrease* in the transverse diameter. In some subjects the decrease was gradual and progressive during the test; in others it was a sudden diminution at the end. Analyzing them according to their probable causation, we may divide these also into three varieties or groups.

The first group includes those in which the changes are evidently due to varying phases of respiration at the moment of exposure. Cases 51, 82, 114, 121, 139 and 151 are explainable in this way. All of these subjects really belong to the class of cases in which there was no significant change in the transverse diameter, or rather the class in which the change in the transverse diameter represents a displacement rather than a true enlargement of the heart.

The second variety of cases showing diminution of the transverse diameter, includes five subjects (Table 1) all of whom showed symptoms of circulatory failure at the end of the rebreathing test.

Case 53 went to 9.5 per cent of oxygen in 27 minutes and 50 seconds. His systolic blood pressure remained constant at about 120 mm. of mercury until the twenty-sixth minute, when it fell suddenly to 80 mm. at the twenty-seventh minute. The diastolic began at about 78 mm. and rose somewhat irregularly to 88 mm. at the twenty-fifth minute. During the next two minutes it fell to 42 mm. of mercury. The pulse pressure remained fairly constant around 35 mm. during the run; but

TABLE 1

CLASS III, GROUP 2.—Transverse diameters and areas of the heart silhouette made at 75 cm.

Exposure	Case 53		Case 122		Case 144		Case 142		Case 83	
	T. D. (cm.)	Area (sq. cm.)	T. D. (cm.)	Area (sq. cm.)	T. D. (cm.)	Area (sq. cm.)	T. D. (cm.)	Area (sq. cm.)	T. D. (cm.)	Area (sq. cm.)
1	15.4	175	14.7	142	11.8	136	16.	162	13.4	150
2	14.5	161	15.5	142	12.	139	15.7	156	12.75	145
3	14.6	165	14.5	136	12.5	138	15.5	160	13.	144
4	14.5	165	14.9	137	12.4	144	15.8	150	12.8	143
5	....	...	15.2	142	12.	127	14.4	161	13.1	149
6	....	...	14.1	135	....	...	....	...	.....	...
Av. in run	14.7	166	14.9	13.9	12.1	137	15.3	157	12.85	146
End of run	11.9	135	13.8	119.	11.3	116	14.4	142	12.	132
Prelim. (insp.)	13.5	149	Double	Exposure	11.9	138	13.5	152	12.5	144
Post. (insp.)	13.5	160	14.4	Double E7.	11.4	129	13.8	150	13.	148

Note. The numbered exposures are those made during the rebreathing test. They were made approximately five minutes apart, except that at the "end of run" which was made as nearly as possible at the moment of the termination of the test. Estimation of the area is usually uncertain in double exposures. The figures are not entered in such cases.

after the subject was removed from the rebreathing machine it went down to 20 mm. at the thirty-second minute. The pulse rate remained between 70 and 75 for ten minutes, and then rose gradually to 108 at the end of the test. At the twenty-seventh minute the subject lost consciousness in a typical vaso-motor faint. As is shown in Table I, the transverse diameter remained at about 14.5 cm. to the twenty-fifth minute. At the twenty-seventh minute, at the moment of the faint, it was 11.9 cm. We believe that this sudden diminution of the transverse diameter was caused by dilatation of the splanchnic vessels, so that the venous pressure was not sufficient to fill the heart during its diastolic relaxation. The roentgenogram shown at the moment of the faint is therefore that of an empty heart.

In this case the high position of the shadow of the lead line on the sternum as compared with the "O" over the dorsal spinous process is due to a straightening of the upper dorsal spine and an elevation of the sternum which accompanied the falling backward of the head at the moment of the faint. Comparing the lateral displacements of the dorsal and the sternal marker in radiographs obtained before the run, at the moment of the faint, and after recovery from the faint, it is evident that there was no rotation at the time of the faint. The position of the diaphragm is not shown in as full inspiration at the time of the faint as it is in the preliminary plate or in that after recovery. Neither respiratory phase nor rotation of the body of the subject at the time of fainting will account for the suddenly decreased transverse diameter of the cardiac shadow. The evidence seems fairly conclusive that a sudden paralysis of the splanchnic vessels formed a large reservoir into which the blood was drained away from the peripheral vessels. As long as this drain merely removed blood from the arteries without too greatly lowering the venous pressure, there was a lowering of both systolic and diastolic pressures with little change in the pulse pressure. But as soon as the venous pressure was markedly lowered and the cardiac output per minute was diminished, the pulse pressure was lowered, and fainting supervened. Judging by analogy with other cases where it was possible to obtain it, the pulse pressure in case 53 was much lower at the time of the loss of consciousness (cf. *Air Service Medical*, 1919, No. 144, opp. page 225.). As the vena cava began to fill up again and the heart to obtain more blood to pump, the diastolic pressure would first be raised. Unless there was a simultaneous contraction of the arteries, there would result a lowering of the pulse pressure, coincident with an improvement in the blood supply to the brain and a return to consciousness.

Case 122 ran thirty-six and a half minutes, at which time he was breathing air containing only 5.2 per cent oxygen. He was then cyanotic and unconscious, but not relaxed. There were moderate convulsive twitchings of the hands, face, and head. The systolic blood pressure rose from 130 mm. at the beginning to 150 mm. at the thirty-third minute. The diastolic gradually fell from about 80 to 46 during the same period. The pulse pressure increased steadily from 50 mm. to 104 mm. at the thirty-third minute. Surely here, if ever, we would expect to find evidences of heart strain and dilatation. Plates exposed at the twenty-fifth and thirtieth minutes, at the height of inspiration showed transverse diameters of 14.9 cm. and 15.2 cm. The thirty-four minute plate, taken also at the tip of inspiration, shows a transverse diameter of 14.1 cm. At this point both systolic and diastolic pressures were falling. The thirty-six and a half minute plate was taken in full expiration. It showed a transverse diameter of only 13.8 cm. The kymograph tracing showed a marked increase in the depth of the respiratory movement during the last ten minutes of the run. We believe the first decrease in the transverse diameter to be attributable to this cause. The respiratory-minute-volume remained below 70 decilitres until the twenty-fifth minute, but increased rapidly thereafter to 165 decilitres. The second decrease in the transverse diameter

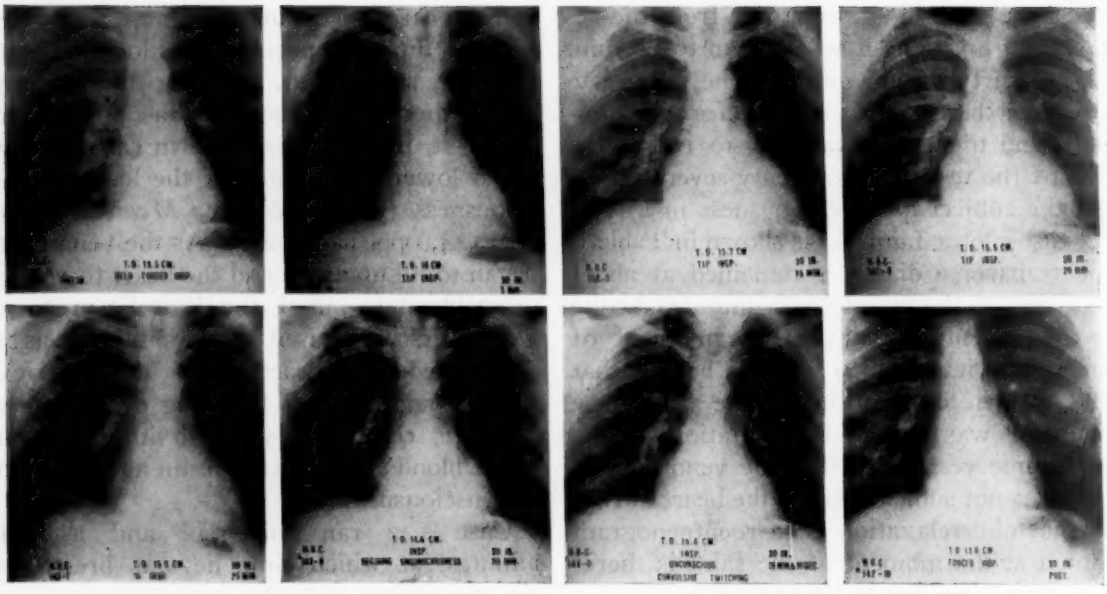


FIG. 21. CASE 142. UNCONSCIOUSNESS WITH DECREASE IN T. D. AND DIAPHRAGM IN EXPIRATORY POSITION AT 30 MIN.

from 14.1 cm. in inspiration to 13.8 cm. in expiration seems fairly attributable to vasomotor collapse similar to that of the preceding case. The thirty-six and a half minute exposure was made after the blood pressure readings were taken. Had it been possible to take another reading before the subject was removed from the rebreathing apparatus, we believe that a further fall of the systolic and diastolic blood pressures would have been found.

In Case 144 the transverse diameters decreased from a range of 12 to 12.5 cm. during the first thirty minutes of the run, to 11.3 cm. at the thirty-second minute. At this point the test was terminated, the subject being completely inefficient and barely conscious. The final oxygen percentage was 6.5 per cent. During the last two minutes of the run, the systolic blood pressure fell 20 mm. The pulse pressure was then 34 mm. Hg. Two minutes later, the pulse pressure was 25 mm. Hg. The decrease in the transverse diameter in this case also seems to have been due to the lowered blood pressure not completely distending the heart during diastole.

Case 142 is shown in Figs. 8, 9 and 21. The transverse diameter during the first twenty-five minutes of the test varied from 15.5 to 16 cm. It was 14.4 at thirty minutes, and the same at thirty-one minutes and ten seconds when the test was terminated. At this point the subject was breathing 7 per cent of oxygen. He was pale, unconscious, with rigid muscles and fixed jaws. There were slight irregular jerking movements of the head. The pulse was barely perceptible, and the respiratory movements were absent. The cessation of breathing was noted clinically, and is also shown on the kymograph tracing. The subject presented the picture of oxygen want so frequently observed in approaching dissolution accompanied by circulatory failure. When he was removed from the machine and allowed to breathe pure air (after slapping his chest), his recovery was fairly rapid, but not immediate, as is usually the case after the runs on the rebreather. The chart shows that the systolic blood pressure fell 15 mm. during the thirtieth minute, and the diastolic fell 20 mm. during the twenty-ninth and thirtieth minutes, just before the first exposure showing contraction. It may be noted in passing that the diastolic blood pressure is always the first to break. At thirty-one minutes, when the last plate of the run was taken both blood pressures were

still falling. The last plate was taken during the period of apnea, and was obtained during mid-phase respiration or even expiration, as is shown by the kymograph record. The preceding plate with the same transverse diameter was obtained in inspiration. It seems reasonable to think that the measurement would have been smaller had this last exposure been obtained in *full inspiration* like the others.

Case 83, the fifth of this group, was of the vaso-motor fainting type. He fainted during the preliminary examination, before he even saw the rebreather; a faint caused the termination of the run, and he had to have his head between his knees after the control plate following the run. The transverse diameter at the time of his second faint was 1 cm. smaller than at any time during the run, and ½ cm. smaller than that in the preliminary plate taken in forced held inspiration. The roentgenogram made during the faint was also in the expiratory phase, and the systolic blood pressure was 32 mm. Hg.

The foregoing five cases are typical examples of the way in which the circulation usually fails from oxygen want. It is primarily a vasomotor failure, and only secondarily cardiac. The end result, of course in either case, is a faint. But the emphasis in our methods of selection of aviators, so as to eliminate such accidents as fainting in the air, will be entirely different, according as we regard the faint as primarily cardiac in character and arising from "heart strain," or as we regard it as fundamentally vasomotor or neuro-circulatory in origin.

The three remaining cases in which there was a decrease in the transverse diameter form the third group, and one which is not easily explained. There was no evidence of circulatory failure during the run, and varying phases of respiration are not discernible in the plates or in the respiratory tracings.

In Case 28 (Table 2) five plates taken during the first twenty-seven minutes of the run gave each a transverse diameter of 14.75 cm. The next plate made at thirty minutes, shows a transverse diameter of 14 cm. The subject was then unconscious, sitting rigidly in his chair, slightly cyanotic, but the circulation well maintained. The systolic and diastolic pressures were unchanged. Pulse rate had increased from 66 at the start to 105; it was of good quality. The respiratory volume was high throughout. Toward the end, it fell from 173 decilitres per minute during the twenty-eighth minute to only 20 and 30 decilitres per minute for the two minutes following. The small diameter picture was obtained after these two minutes of remarkably small minute-volume respiration. The radiographs show the diaphragm to be slightly higher in the 14 cm. plate than in those with the larger transverse diameter.

TABLE 2.

Case 28. Heart measurements during rebreathing test. Target distance 75 cm.

Exposure	T. D. (cm.)	Area (sq. cm.)
5 min.	(Plate broken)	
15 "	13.50	170
20 "	13.11	158
25 "	13.20	156
30 "	13.40	157
34 " (end)	12.00	132
Post.	(Double exposures)	

In Case 100 (Table 3) the diaphragm is also slightly higher in the final plate of the run than in the preceding ones. The kymograph tracing likewise shows all exposures to have been made in full *inspiration* except the one with the small transverse diameter, which is shown to have been exposed a little below the apex of the curve. The decrease in the diameter is 1.4 cm.

TABLE 3.

Case 100. Heart measurements during rebreathing test. Target distance 75 cm.

Exposure	T. D. (cm.)	Area (sq. cm.)
5 min.	14.75	136
13 "	14.75	140
15 "	14.75	145
20 "	14.75	149
25 "	14.75	151
End	14.00	134
Post. (insp.)	14.50	147

Case 30, which shows a decrease from an average of 16.5 cm. during the run to 15.6 cm. at the end, must also be included in this group of unexplained cases of apparently real decrease in the size of the heart.

These three cases are all excellent ex-

amples of a large class of healthy subjects, who become what the psychologists somewhat technically term "inefficient" under the conditions of low oxygen pressure. Such men frequently show little or no effect of their oxygen want in their circulatory mechanism. Apparently their psychomotor nerve centers are more sensitive to oxygen reduction than are their circulatory centres. It seems possible that in certain persons oxygen reduction acts like moderate exercise to reduce the size of the heart. It is also possible that moderate oxygen reduction in the circulating blood acts in all cases like moderate exercise to cause decrease in the size of the heart. Under such circumstances the decrease would usually occur during the early part of the run, but exceptionally it might not appear until later, as in Cases 28, 30 and 100. It would be small in amount and in most cases overshadowed by the changes due to the varying position of the diaphragm. The fact that in our series, the transverse diameter during forced inspiration after the rebreathing run is almost always smaller than it is before the run, gives support to this assumption of normal cardiac contraction during the rebreathing test. More accurate determination and control of the respiratory phase at which the radiographic exposure is made, may in the future enable us definitely to decide this point.

Just what relation, if any, the enormous increase in the respiratory minute-volume bears to the reduced diameter of Case 28 and to the increased transverse diameter of Case 110 is difficult to determine. In Case 28 we might suspect that the greatly increased minute-volume of respiration so freed the blood from carbon-dioxide that its effect in diminishing the tonus of the heart muscle was lost, and the oxygen, even though reduced, had an exaggerated stimulating effect upon the muscle tonus. The sudden fall in the minute-volume of the respiration during the final two minutes of the run would seem to point to a diminution of the carbon dioxide content of the blood below the threshold at which this respiratory center is simulated by CO_2, and to indicate that oxygen want alone was not a sufficient stimulation. On the other hand, we might suppose that in Case 110, showing enlargement, the carbon dioxide was not pumped out of the blood fast enough to reduce the blood content below the threshold of respiratory stimulation, and that it was still present in sufficient quantity to more than counteract the stimulus to muscle tonus of the reduced oxygen supply. This, however, is only speculation. Unless these discrepancies can be traced to some defect in our method, we must for the present leave them unexplained, awaiting a fuller knowledge of the physiological effects of oxygen reduction in the blood.

In order to help determine whether the changes in the transverse diameters which we have described represent a true contraction or enlargement of the heart, the areas of the heart shadows were obtained with a planimeter. To do this, we outlined the heart on the glass side of the plate and followed the outlines thus obtained with the needle of the planimeter with the aid of light transmitted through a window in a table top. The method of outlining advocated by Shattuck [1] and by Bardeen [2] was used. That is, the right and left borders of the heart were drawn as far as they were clear and distinct, and then these two lines were joined by a smooth curve continuous with them at either end (Figs. 11 and 12). This method unquestionably cuts off a portion of the left auricle and includes a portion of the great vessels at the base. However, we have found it to give more uniform results when repeated on the same pictures at subsequent sittings than are obtained by trying to draw the true outline of the auricle and the anatomically indefinite junction of the great vessels with the heart. By administering to the subject tartaric acid and soda bicarbonate separately in half seidlitz powder doses, the resulting gas in the stomach aids in giving a fairly complete outline of the lower border. Practice with the well outlined shadows enables one to draw those

[1] Shattuck, *Bost. Med. & Surg. Jour.*, March, 1916.
[2] Bardeen, *Am. Jour. Anat.*, March, 1918.

in which the outline is masked by other shadows with a fair degree of uniformity and accuracy.

Our studies along these lines have caused us to draw the lower border with a slightly more rounded outline than does Bardeen. He draws it rather flattened, with sharp curves at its junction with the right and left borders. Our reasons for drawing a more rounded outline (Fig. 11) are some rather extensive outlines we have obtained in the living subject by means of the gas bubble in the stomach, and the fact that by so doing we have obtained more uniform results in the different plates from the same subject. While in a few of our cases with extensively shown heart outlines, the lower border has been flattened, we believe that it is more often rounded, especially during inspiration, the time at which most roentgenograms are obtained. The shape of the heart as well as its position in the cadaver is that of relaxation, and is not that of the functioning organ. We also believe that the rather thin and sharp lower border of the heart is transparent to the roentgen rays and that frequently the shadow which in the silhouette is thought to be the lower border, is really the lowermost portion of the blood-filled ventricular cavity (Fig. 16). Occasionally in forced inspiration we have obtained exposures showing an apparently complete separation between the heart and the diaphragm. We believe that this seeming space is really occupied by the comparatively transparent thin muscular tissue of the lower border.

Comparing the areas obtained in this way with the transverse diameters during the rebreathing run, we found that in Case 30, where there was apparent contraction at the end of the run, the areas did not show any decrease in size.

Case 28 (Table 2) shows a difference of 17 sq.cm. between the largest and smallest area of the silhouette, but the five minute shadow and that at the end of the run show only 2 sq.cm. difference.

Case 100 gives the measurements shown in Table 3. There is a difference of 38 sq.cm. between the largest and the smallest areas; and of 28 sq.cm. between the smallest area and the average area for the rest of the run. This is the greatest variation of the area in our series, and seems to us to indicate the possibility that a real contraction of the heart has occurred in this case. On the other hand, in Case 28 the areas at the beginning and at the end are so nearly the same that we cannot postulate any real change in the size of the heart.

The areas in the five cases showing symptoms of circulatory failure are shown in Table 1, together with the transverse diameters. On the whole, the decrease in the areas corresponding to the decreased transverse diameters is very consistent, and tends to support the theory of an actual diminution of the size of the heart in these cases.

Our cases are as yet so few in number that we have not attempted to decide what are the limits of error in the estimation of the size of the heart from the area of its radiographic silhouette. Case 28 shows a variation of over 10 per cent. Where a series of exposures are made of the same subject and an average area obtained, such an error might be admissible; but when it is desired to obtain an accurate knowledge of the size of the heart from one or two plates, 10 per cent of possible error is too great. We recognize that the error in the estimation of the silhouette area arises partly from varying phases of respiration and the varying degrees of masking of the lower border by the diaphragm; but after all, the difficulty of outlining the upper and lower borders is inherent in the method, whatever the respiratory phase. This difficulty is especially noticeable in the broad flat hearts of stocky individuals having a tendency to overweight.

While theoretically the area of the radiographic silhouette should give a more correct indication of the size of the heart than the transverse diameter, we believe that practically the transverse diameter is a very useful measurement. This is especially true if care be taken to adopt a standard phase of respiration in which to make the exposure. As our studies indicate, the changes in the trans-

verse diameter are less marked in ordinary breathing than in forced breathing. On the other hand, the heart is seen in better outline during inspiration. Therefore, the exposure made in moderate inspiration, as is customary among roentgenologists, is the rational one, whether we are looking for the silhouette area or the transverse diameter. However, certain precautions are necessary as to the time of the exposure. The subject may be able to hold his breath for a considerable period, but his diaphragm will very soon begin to creep either upward or downward. We have taken roentgenograms of subjects holding their breath (Fig. 16) while the nostrils were closed with a spring clamp, such as that used with the rebreather or in the older form of gas mask. Notwithstanding the apparent impossibility for air to escape from the lungs, the diaphragm gradually changed its position. Even when holding the breath for a brief period, unless the subject is thoroughly trained, involuntary efforts to breath will produce changes in the relative positions of the chest wall and diaphragm, which move backward and forward, and upward and downward in the heart silhouette under such conditions apparently are not all due to diaphragmatic change of position.

In determining the phase of respiration, a simple respirometer is very helpful, exposure being made when the counterweight reaches the proper elevation. We hope to make further observations on the size of the heart in aviators from silhouettes taken when the exposure is automatically set off at a standard phase of respiration. The position for the drum at the time of the exposure can readily be determined from a knowledge of the volume of tidal air when the subject is breathing quietly. This point being decided, all we have to do is to cause a counter-weight to close an electric circuit, which in turn actuates the *x*-ray switch.

As will be seen from Table 4, which shows the summary of the true measurement of the heart as calculated from the 75 cm. silhouette, the hearts of aviators are slightly larger than the standard measurements usually given for young subjects. We believe, however, that these measurements are unusually accurate in that they represent averages of from three to nine silhouettes

TABLE 4

TRANSVERSE DIAMETERS AND AREAS OF HEART CONTOURS CORRECTED FOR PARALLEL RAYS

TRUE MEASUREMENTS OF THE HEART IN RELATION TO WEIGHT GROUPS

Weight Group Lbs.	Average Weight Lbs.	No. of Individuals in Group	Controls				Rebreathing Test					
			T. D. (cm.)		Area (sq. cm.)		T. D. (cm.)			Area (sq. cm.)		
			Insp.	Exp.	Insp.	Exp.	Max.	Min.	Average	Max.	Min.	Average
120-129	125.	6	11.9	12.4	107.5	103.7	13.8	11.8	12.2	121	93	104.5
130-139	134.8	12	12.2	12.8	118.1	117.7	13.9	10.3	12.3	136	104	116.5
140-149	143.	24	11.8	13.3	111.1	116.3	15.3	9.6	12.4	141	82	112.8
150-159	152.6	24	12.3	13.7	120.4	120.2	15.0	11.7	12.8	145	86	119.0
160-169	162.8	9	12.9	14.1	119.7	126.9	14.4	13.4	13.6	145	107	122.8
170-179	171.	9	13.1	14.6	116.8	121.5	15.6	12.5	13.5	138	106	122.3
186	.....	1	14.4	15.1	134.	135.	14.2	13.5	13.9	133	124	128.

reciprocal action and reaction. Care should therefore be taken to make the exposure the moment the respiration reaches the desired phase, or at the beginning of the held breath. Cases 135 and 137, illustrated in Fig. 13, illustrate the changes in the position of the diaphragm when the nose is clamped and the breath held for as long as possible. Incidentally, we may note that the changes for each heart. It is possible that they represent an enlargement due to flying at high altitudes, as is claimed for French aviators by Etienne and Lamy. We are inclined to think, however, that our measurements represent rather the heart of the soldier in general, or perhaps the undamaged heart of the athlete, from which class a large proportion of our aviators is drawn.

TABLE 5

Variation of the transverse diameter and of the area of the heart contour during Expiration and Inspiration and during the Rebreathing Test. Measurements at 2 metres and at 75 centimeters corrected for parallel rays.

Case No.	Weight (lbs.)	Height (ins.)	Controls				Rebreathing Test						
			Transverse Diam. (cm.)		Area (sq. cm.)		Transverse Diameter (cm.)				Area (sq. cm.)		
			Insp.	Exp.	Insp.	Exp.	Total No. of Exposures	Max.	Min.	Average	Max.	Min.	Average
5	160	71.	12.6	.....	116.	.....	7	13.9	13.5	13.6	132.1	123.2	128.1
21	153	69.5	13.9	.....	119.2	.....	5	13.6	12.2	12.7	122.4	106.4	115.2
22	158	70.5	14.4	.....	138.0	.....	5	13.2	13.	13.1	128.8	119.5	125.6
23	150	69.5	12.1	.....	134.4	.....	5	12.6	12.2	12.4	129.7	119.3	12.2
26	151	71.	12.6	12.6	122.1	117.8	6	12.5	11.7	12.1	110.6	101.7	105.9
28	142	70.	13.0	.....	118.0	.....	5	13.2	12.6	13.1	121.1	107.4	117.0
30	150	67.	13.6	.....	117.8	.....	4	15.	13.5	14.4	124.0	117.4	119.3
32	144	68.75	10.6	12.3	86.4	84.	..	12.1	11.0	11.3	92.8	81.8	87.3
34	140	70.	11.5	.....	102.3	.....	7	12.6	11.2	12.2	126.4	98.9	113.9
37	150	67.	10.4	13.0	80.0	82.3	5	12.7	11.8	12.9	104.	85.8	108.1
38	120	65.	11.2	.....	91.7	.....	9	12.4	11.2	11.6	108.6	92.9	94.6
39	165	69.	14.0	14.4	117.0	110.0	4	14.13	13.86	13.95	118.	111.0	115.0
40	145	69.5	11.6	.....	94.0	104.0	5	12.6	12.1	12.3	107.2	101.6	104.0
41	143	71.5	10.4	11.7	95.8	95.8	7	10.8	9.6	10.2	97.0	81.8	94.6
44	170	70.	13.2	.....	128.8	.....	5	13.	12.6	12.7	126.7	122.6	124.1
45	148	68.5	12.1	.....	109.6	.....	5	13.2	11.9	12.8	123.8	107.	114.7
47	145	68.5	12.5	.....	111.	.....	6	15.3	13.9	14.5	125.6	109.6	116.
48	172	69.5	13.7	.....	110.4	.....	5	15.6	13.7	13.3	119.2	109.6	114.7
51	123	67.5	12.1	....	116.8	....	5	12.6	12.1	12.4	120.	109.6	114.4
52	170	69.	13.9	.....	.....	.....	6	15.3	14.5	14.8	.....	.....	.....
53	165	70.5	12.1	.....	119.2	.....	5	13.8	12.1	13.6	140.	128.8	132.8
55	124	67.	11.46	11.97	105.	91.	5	12.6	11.9	12.2	102.	94.	99.
58	125	67.	11.	11.52	98.	91.	5	11.8	12.3	12.2	103.2	96.8	100.
61	165	71.	13.5	.....	100.	125.	4	14.4	13.9	14.2	112.8	109.2	110.
62	140	71.	12.6	14.4	123.	135.	5	13.	13.6	13.7	140.	129.6	132.8
71	134	69.	Double	Exposure	Double	Exposure	5	12.	10.8	11.7	136.	104.8	123.7
73	170	61.	13.	14.4	116.	117.	3	13.5	12.6	13.3	125.	106.	116.6
74	129	67.	12.6	13.	124.8	113.	6	12.7	12.2	12.5	115.6	103.	110.
76	138	66.5	12.5	13.8	118.	123.	5	13.7	13.5	13.6	121.	116.8	118.
77	140	66.	12.5	13.0	118.	123.	7	13.5	12.7	13.5	121.6	116.8	118.
82	165	72.	12.9	13.9	121.2	117.	4	13.5	12.1	12.9	128.2	107.9	117.9
83	137	68.	11.3	12.2	115.2	116.8	6	12.	10.8	11.6	124.	106.	116.9
84	130	70.	12.6	13.2	123.6	127.9	7	12.9	12.4	12.7	120.6	110.6	114.7
85	140	70.	13.1	13.9	123.	117.	5	13.4	12.5	13.	128.8	107.2	125.9
87	136	71.	14.4	15.1	133.7	135.4	5	14.2	13.5	13.9	132.9	123.6	128.4
88	132	69.5	13.	14.1	133.6	129.2	5	14.3	13.4	14.	143.7	125.	134.1
89	132	68.	13.9	11.7	132.4	114.2	6	12.5	11.5	12.1	122.4	108.8	116.6
90	140	61.	11.9	12.6	109.8	110.4	6	11.9	11.3	11.8	113.3	107.9	110.6
91	140	66.	13.1	13.6	119.4	118.8	6	13.6	12.9	13.3	117.6	112.9	115.
92	138	64.	10.3	12.1	93.	107.5	6	12.1	10.3	11.5	112.8	100.8	107.
93	127	66.	13.2	13.3	114.5	116.	5	13.8	12.7	13.1	120.9	109.7	114.5
94	135	68.	12.2	12.2	108.8	109.6	5	12.8	12.4	12.5	112.7	108.	110.6
96	148	70.5	10.4	11.9	.....	.....	6	12.2	10.8	11.4	104.8	95.4	99.7
97	150	70.	12.6	13.9	126.4	124.8	6	13.6	13.	13.4	132.9	117.	121.3
98	172	70.	Double	Exposure	Double	Exposure	4	12.6	12.5	12.58	122.8	112.	116.8
99	165	72.	12.2	13.	126.5	139.8	5	14.1	13.2	13.8	144.9	128.2	140.2
100	134	69.75	12.7	13.1	136.	123.2	6	12.1	11.8	12.	136.	124.8	128.
102	141	62.5	9.5	12.3	88.8	.....	6	11.2	10.3	10.6	108.3	95.3	98.4
103	158	73.	10.7	.....	106.4	.....	2	12.4	12.	12.2	117.8	112.8	114.8
104	154	69.	11.8	14.4	142.4	116.8	3	13.1	12.4	12.7	125.6	112.8	119.6
105	170	70.	12.4	.....	112.	.....	4	13.9	13.5	13.7	128.7	116.7	123.8
106	153	69.	Double	Exposure	Double	Exposure	5	13.7	13.1	13.3	126.5	116.	122.3
107	128	66.5	12.	.....	105.6	.....	2	12.	11.3	11.7	102.	100.	101.
108	135	71.	Double	Exposure	Double	Exposure	3	12.1	11.7	11.9	112.	98.8	105.7
109	152	71.5	12.3	13.3	Double	Exposure	5	12.3	12.1	12.1	128.9	119.5	124.2
110	141	71.3	11.3	13.5	Double	Exposure	5	12.3	11.7	12.1	120.4	110.	114.5
112	140	70.	10.3	13.	Double	Exposure	5	12.6	12.1	12.3	132.4	121.9	126.5
114	152	71.5	Double	Exposure	Double	Exposure	5	12.8	12.4	12.6	113.	107.8	109.2
115	150	68.	13.1	14.5	121.5	129.6	5	13.7	13.3	13.5	136.	125.1	130.5
116	160	68.	12.4	12.6	101.6	126.	5	14.4	13.9	14.	140.1	124.	128.7
118	175	73.	Double	Exposure	Double	Exposure	3	14.4	13.5	13.6	138.2	136.7	137.4
119	135	69.	.....	14.7	Double	Exposure	5	13.9	13.3	13.5	127.	119.	122.
120	170	69.	13.	14.8	Double	Exposure	4	15.4	13.9	14.3	129.6	120.	124.
121	155	68.5	12.8	14.5	Double	Exposure	3	14.4	13.5	13.8	129.6	119.	123.
122	140	67.	13.5	14.4	Double	Exposure	7	13.9	12.4	13.2	113.9	95.6	109.1
123	154	71.75	12.2	13.0	117.2	106.4	4	12.8	12.2	12.5	115.2	104.8	110.4
125	145	68.5	11.8	13.5	112.	111.7	5	12.9	12.7	12.8	110.7	101.5	102.5
126	160	69.	13.5	14.4	119.	111.	5	14.0	13.6	13.9	117.6	107.2	113.9
131	155	67.	12.9	13.	.....	.....	5	13.	12.8	12.9	109.	104.	107.7
132	152	71.	12.1	13.8	120.	119.	5	12.8	12.3	12.5	132.	115.	123.6
133	162	67.	13.3	15.2	131.2	136.	6	13.7	13.5	13.6	144.	122.	127.
134	145	68.	11.4	14.4	103.	125.3	7	13.7	12.4	13.1	109.5	102.	106.
135	146	71.	12.	13.	125.	115.	5	12.2	11.5	11.8	119.	107.	114.6
136	150	66.	12.6	14.1	109.6	109.	5	13.5	13.1	13.3	116.	110.4	113.
137	145	70.	11.9	13.9	125.6	108.0	6	12.6	11.9	12.3	121.6	105.6	114.4
138	159	69.	11.7	14.5	119.2	138.4	5	13.9	13.7	13.8	144.0	130.4	136.
139	170	72.	12.7	14.6	116.8	125.6	5	14.0	13.5	13.8	124.8	115.	121.
140	....	....	11.7	12.9	98.4	105.6	3	12.1	12.1	12.1	112.	108.	110.
141	150	70.5	11.5	13.5	119.	120.	2	12.1	11.7	11.9	112.	108.	110.
142	143	68.	12.2	14.4	117.	124.8	6	14.4	13.	13.8	129.9	114.2	123.5

TABLE 5—*Continued*

Case No.	Weight (lbs.)	Height (ins.)	Controls				Rebreathing Test						
			Transverse Diam. (cm.)		Area (sq. cm.)		Transverse Diameter (cm.)				Area (sq. cm.)		
			Insp.	Exp.	Insp.	Exp.	Total No. of Exposures	Max.	Min.	Average	Max.	Min.	Average
143	135	71.	12.1	13.1	.....	121.6	5	13.5	11.8	12.6	133.6	108.	117.6
144	146	71.	10.3	13.1	104.	120.8	6	11.2	10.1	10.8	115.	92.8	109.
146	135	68.5	12.5	15.2	131.2	144.	4	14.4	14.2	14.1	145.6	136.8	140.8
147	161	70.	12.9	14.9	124.8	140.	5	13.4	12.6	13.1	121.	109.6	113.
149	164	68.	14.	14.2	.....	120.9	6	14.0	13.	13.5	124.	115.	120.
151	150	68.	12.3	14.1	108.	119.	5	13.5	12.7	13.1	119.	100.	108.
152	155	71.	12.6	14.8	130.	152.	3	14.2	13.	13.3	140.8	130.	135.6
153	155	70.5	12.	12.9	124.	123.	5	13.1	11.7	12.7	122.	116.	119.
154	152	71.	11.7	13.	110.	107.	5	12.6	12.2	12.4	123.	106.	114.8
156	160	69.	12.1	15.	131.	143.	4	13.7	13.5	13.6	142.	129.	138.8

[NOTE.—In Tables 4 and 5, the measurements given are the true diameters and the true areas of the contour of the heart as calculated mathematically. For this purpose the plane of the contour of the heart which gives the silhouette is assumed to be parallel to the plate, and its distance from the plate 8 cm. It is admitted that the plane of the contour may not be absolutely parallel to the plate in many or even in all cases. The silhouettes will evidently be distorted in proportion to the departure of the plane of the contour from parallelism with that of the plate. An effort was made in our work to reduce this distortion to a minimum by having the back of the chair tilted slightly forward so as to bring the gladiolus of the sternum parallel to the plate as recommended by Bardeen. The distance of 8 cm. from the plate for the contour is larger than usual because we were compelled to allow for the movements of the chest during the deep breathing which our subjects indulged in during the progress of the test. The sternum was not always in contact with the plate. As our work was undertaken primarily to compare the heart measurements obtained during the course of the rebreathing test in the same subject, and not those of one subject with another, we believe that the possible distortion resulting from these departures from the standard method is negligible.

In order that our measurements may be compared with those of other observers, we have endeavored to convert them as accurately as possible into the true measurements of the heart contour. We have done this on the formulae that the true diameter and the silhouette diameter are directly proportional to their distance from the target; and that the two areas are directly proportional to the squares of their distances from the target. Assuming the heart contour to be 8 cm. from the plate, these formulae give the following relations:

With heart 8 cm. from the plate

Target 2 meter distance
True T. D.=96 per cent t. d. of silhouette
True area=92 per cent area of silhouette
Target 75 cm. distance.
True T. D.=89.6 per cent t. d. of silhouette
True area=79.6 per cent area of silhouette

DISCUSSION OF ARTICLES ON THE HEART BY DRS. VAN ZWALUWENBURG, HOLMES AND LE WALD

DR. A. W. CRANE.—Dr. LeWald's work is certainly one of great interest and has involved the construction of new and strange apparatus. It will be remembered that Dr. LeWald's plates showed an enlargement chiefly to the left, occasionally a little to the right. I think that the doctor did not insist in any case that this was a true dilatation of the heart. It would seem rather to be an "effort-syndrome" of the heart without muscular or valvular decompensation. The most interesting point to me was that the signs produced by this effort disappeared with the administration of oxygen. The effort of the heart is put forth by reason of the diminished oxygen in the blood rather than because of the diminished

atmospheric pressure or increased work. This is true research, and more of that work is needed.

The paper of Dr. Van Zwaluwenburg would be a joy to discuss, but our time prevents full discussion of it. There is no reason why there should be any antagonism between the fluoroscopic estimation of the heart's outline and the estimation by the Bardeen method of a plate at six feet distance. The fluoroscopic method means making dots along the outline and introduces the variant of the personal equation. It also necessitates special apparatus. If you want to do it there is no reason why you should not, but it is a saving of time to take the plate at 6 feet and make the necessary reduction. This requires only apparatus that you have in your office.

The estimation of heart-volume by diameters in comparison with estimating the heart-volume by taking the square area, seems to me to admit of no argument whatever. There is no set of diameters that you can rely upon. But you may obtain the square area easily by that little instrument in use by engineers, the planimeter. There is no mathematical formula for estimating an irregular outline such as the heart silhouette. It seems an error to try any mathematical calculation for estimating this silhouette.

Not only can you estimate the heart-volume by the Bardeen method, but you can also estimate the approximate weight of the heart muscle and the weight of the heart-blood. This does not mean that you will not use the fluoroscope and observe the beating chambers and make other observations, but it does mean that when it comes to the estimation of the size of the heart, we should use the Bardeen method.

Dr. Bardeen has put into our hands a set of tables which represent the fruits of his work. So far as I know, there are no other tables accessible which compare in accuracy whereby we can recognize heart-volume in relation to body-size, weight and age. We can take pride in the work of Dr. Bardeen as that of an American.

I must pay my compliments to Dr. Holmes, and I believe that this work which he is doing will put the study of the pericardium on a sounder basis for clinicians as well as for roentgenologists.

Dr. George E. Pfahler.—I have been very much interested in the study of the heart. The question of outlining the heart by the orthodiagraph, as far as estimating the size of the heart, has never appealed to me strongly. You cannot ignore it, but it is only the gross changes that become important. It is very difficult to estimate how large the size of the heart of any man here should be; if we can't tell that, it is extremely difficult for us to tell our patient how large his or her heart should be. There is no man here who could tell me how large my little finger should be, because my occupation and my ancestry and other things come into play just as they come into play in estimating the size of my heart. I do not believe we should attach too much importance to the size of the heart. I believe we should attach more importance to the strength of the heart and the force of the contraction, and there is where I think fluoroscopic examinations come into use. With experience you can judge the strength of the heart's contractions and the strength of the heart muscle, and that after all is more important than its size.

Dr. L. T. LeWald.—I am much interested in Dr. Holmes's work. I did a series of investigations on the cadaver and used lead acetate ti simulate the density of the effusions as Dr. Holmes did with salt solution, and our results were comparable to his work. We were unable to detect the heart shadow inside of the fluid shadow. I think Dr. Holmes's work is going to clinch some of the points that are in dispute and leave us in a position where we can determine the presence of large collections of fluid.

Dr. George E. Pfahler.—I appreciated Dr. Holmes's work very much, but I would like to ask Dr. Holmes whether he considers obliteration of that curve on the left side of the heart as characteristic. He said he observed it in these cases, which we are willing to accept, but to make it of importance we must find whether it is possible to say that it is characteristic or at least always present.

Dr. W. H. Stewart.—It was my privilege to examine a large number of cases of influenza and pneumonia at Debarkation Hospital No. 5, during the epidemic of last winter, a great many of which had pericardial as well

as pleural effusions. I might say that it was very difficult to determine, from the roentgenographic findings, whether or not pericardial effusion was present. Those that went to post-mortem we studied very carefully with Doctor Lambert, and noted, where pericardial effusion was present, that most changes in the cardiac outline occurred at the base rather than at the apex. Of all the cases we saw that went to post-mortem, I do not remember more than one in which the cardio-diaphragmatic angle was obliterated. They all had a very sharp outline, and all effusions in this class of cases seemed to travel up and to increase the width at the base.

Dr. F. S. Bissell.—In our work at the University of Minnesota we have found it advantageous to emphasize the cardiac type rather than the cardiac volume, and in doing that if one is to construct tables which are of value, one must correlate the cardiac type with the individual type, as Dr. Pfahler suggested. It is absolutely necessary to determine before the case is examined under what classification the individual comes and then determine the cardiac type.

Thus in an asthenic individual the aortic type of heart outline is much more significant of actual valvular disease than in the short and broad-chested individual. If the heart is not true to type we are at once suspicious of some pathologic change. Roentgen reports should therefore describe the individual type, the normal heart for such an individual and the type of heart under consideration, the latter being based upon both size and configuration. We find a considerable number of asthenic or drop hearts which are dilated and such cases are best diagnosed by means of the fluoroscope. The characteristic pulsation phenomena of the drop heart shown by an apparent shortening of the long axis and rotation during systole is more significant than mere size. In short it seems to me that there are many considerations in roentgen cardiac diagnosis which are of greater importance than the study of dimensions and cardiac volume.

Dr. A. W. Crane.—I would be sorry to have this discussion close without another opportunity to add something more in regard to the size of the heart. Now the importance of the size of the heart does not have to be settled by roentgenologists; it has been settled by internists in clinical medicine. There is no datum which is more fundamental in cardiac pathology than the size of the heart, and clinicians have long attempted to estimate the size of the diseased heart. Normally the size of the heart is delicately adjusted to the size of the individual. It even varies in size whether sitting, standing or lying. The difference is remarkable, being from 5 to 12 per cent between the upright and horizontal positions. The heart is an elastic body and varies within normal limits at different times in relation to digestion, exercise, etc. It is not to be compared to the size of your nose, which may be large or small as a matter of inheritance. An enlarged heart is never a normal heart. I would maintain that the estimation of the size of the heart in relation to the size and weight of the individual is one of the most important of the cardiac data which we are able to furnish the internist.

Dr. L. T. LeWald.—I think the suggestion in regard to the composite of the heart shadow in a given individual is about as near a correct method to use as we can find, and it is a common method of arriving at conclusions with engineers, that is to make a number of observations and then take a mean. I think it would be correct for us always to do that in arriving at the estimation of the heart's size, and not be content with a single exposure at six feet, but take a group of exposures and average those measurements as worked out by the planimeter.

Dr. James G. Van Zwaluwenburg.—It seems to me that in spite of the apparent disagreement in the discussions, we are not so far apart in the question of measuring the cardiac area, and our position is mainly this: that although the estimation of the cardiac area is important and of value and can be made with more accuracy than the clinician can do it, there is no use in depending on it so religiously and so slavishly as we depend on a scientific instrument of precision. It is a gross measure. Why use an instrument of precision and introduce into a method of approximation an instrument of such refinement as to encourage a feeling of scientific reliability which is not justified? If you want to measure the approximate distance from here to Washington, why make a triangulation? You might just as well take observations of the stars and make an

approximation. The estimation of the cardiac area is only one small item in estimating the condition of the heart.

But we must get all the fluoroscopic evidence, and we cannot recognize the different chambers of the heart by the plate method; I am satisfied of that. I have tried it again and again.

I want to say a word of appreciation of the work of Dr. LeWald. About six years ago I did some work with Dr. Hewlett in an "effort experiment." We tried to determine the behavior of the heart under exercise, and I know something about the difficulties. The fact that the difficulties were so great that we reached no conclusion is the reason the research was never published, and I can appreciate very well the necessary refinements of technique and the difficulties Dr. LeWald has met in reaching satisfactory conclusions.

Dr. W. F. Manges.—In regard to the experimental work in pericardial effusions, can we compare what would happen if we dilated the pericardium suddenly with a pericardium that dilates with the very gradual production of fluid? In other words, is it not true that tissues under tension accommodate themselves in a manner that is different from a sudden dilatation, and can we then take the curves and the shapes that are produced under mechanical dilatation suddenly as an indication of what does occur in pericarditis with effusions where the effusion may be of gradual onset? I recently had occasion to study a patient with a general anasarca. There was an enormous amount of fluid in the abdomen, the heart shadow was enormously enlarged also, and because of the general picture of anasarca I assumed that there was a pericardium filled with effusion. We tapped the abdomen but did not tap the pericardium. The shape of the heart shadow in this instance was much like that of a large heart, perhaps of a heart that had been once hypertrophied and had then become dilated. In other words, it seemed to me there was no comparison between the shape of that heart shadow and one of those artificially produced by pericardial fluid.

Pericarditis with effusion is not always diagnosed, I am quite certain, and that must be clear because at postmortem it is found without there having been any diagnosis made at all. We do not get an opportunity to examine all of the heart cases in our hospital clinics, that is, we do not examine all of them by means of the *x*-ray. It occurs to me that there is still more work to be done along this line; and while the experimental work of Dr. Holmes is very important, I think he needs to carry it out a little further.

Dr. George W. Holmes.—I will first answer Dr. Manges' question and later Dr. Pfahler's. Of course, this experimental work was not done to determine the changes in the shape of the heart. The object of the work was to determine whether or not we could show the heart shadow within the fluid-filled pericardium and incidentally we came upon this obliteration of the cardiac curve. Now the obliteration of the normal curves of the chambers of the heart is not a new observation. Williams calls attention to it in his book and some of the French writers speak of it. I cannot answer positively Dr. Pfahler's question as to whether this obliteration in the normal curves is always present. I should say that in the large majority of cases it is. If careful fluoroscopic observations are made we can usually determine the different chambers in dilated hearts. In pericarditis with effusion or obliterative pericarditis, the outline of the heart chambers is lost.

The final diagnosis in these cases is hard to obtain. It is very difficult to get positive evidence even at autopsy. The pericardium may fill up with fluid after death. A case has been reported in which the *x*-ray examinations and clinical signs suggested fluid and from which pus was obtained by tapping; but at the autopsy the pus was found in the mediastinal cavity and not in the pericardium which contained only serous fluid.

We must have very positive evidence before drawing conclusions from the *x*-ray findings in these cases. I agree with what Dr. Van Zwaluwenburg said. The more of this work you do, the more you come to rely on the fluoroscope. Many good clinicians want to know not the size of the heart but its condition.

The shape of the heart and the strength of its pulsations are of more importance than its size, but its size is of value in checking up percussions; and we must have some method of measurement, but I think we ought not to take it too literally.

REPORT OF SOME INTERESTING THORACIC ANEURYSMS

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CHARLESTON, S. C.

A NEGRO referred from one of the neighboring Sea Islands had a pulsating mass of aneurysm of thoracic eroded through ribs and sternum. This was principally in the second and third right interspace.

Patient was about forty years of age and gave syphilitic history. He was given specific treatment by his physician after our findings with little hope even of improvement and was lost sight of later. These cases are, I am sure, becoming less and less common as better facilities for diagnosis and treatment, even in the remote rural districts, are making the extreme end results of syphilis rarer.

The second case I have to report died in the Roper Hospital, and the courtesy of the staff of the South Carolina Medical College made it possible to follow the history and autopsy findings. A white man of thirty-four was admitted to our outdoor clinic and finally to the hospital in July with a working diagnosis of syphilis and aneurysm of the aorta. The history showed that in 1900 he had gonorrhea and buboes. He had had no specific treatment for any length of time. He used whiskey and tobacco excessively. Had been married nine years. His wife had had several miscarriages and two stillborn children. The wife had lost a large portion of her nose, probably through syphilis.

The patient was quite well until, in November, 1918, while working, he was suddenly taken with pain in his back between the shoulder blades. This was very severe and has continued off and on ever since. It is pulsating and at times affects his breathing. He has a loud, harsh cough and hoarse voice; experiences considerable difficulty in swallowing.

Examination shows dullness and increased vocal fremitus and breath sounds at right apex. There is also some scattered râles and soft systolic murmur. A loud roaring synchronous with heartbeat can be heard under either clavicle, best under the right. Left pulse is slightly stronger than right. Wassermann 4+. He died three weeks after admission.

The roentgen examination showed a mass about the size of a grapefruit filling the upper right thorax. Lateral fluoroscopy showed a large mass blocking the upper mediastinus. This extends back like a large ball and the mediastinum is quite clear below. Unfortunately the lateral plate was destroyed.

The autopsy showed the heart about one and a half times the normal size; competent aortic valves; mitral valves, short hard and rather firmly bound down; tricuspid orifice much dilated; beginning at aortic valve leaflets. Aorta showed fairly uniform thickening. A few yellowish elevated areas are seen on intima of ascending portion. About the middle of the ascending aorta there is globular enlargement. This increased in size as the transverse portion of the arch was approached. The enlargement on inspection appeared completely to surround the aorta which occupied nearly its center. On the posterior wall of the aorta, about midway between the innominate and left common carotid, was a circular opening about seven-eighths of an inch in diameter communicating directly from lumen of aorta to interior of enlargement. The enlargement extended to the left common carotid, where it ended. Its interior was filled with laminated clots, many of which were lying loose, while others were attached.

The walls of this enlargement were composed wholly of the mediastinal tissues, with large quantities of fibrous tissue which had developed in an effort to increase the strength of the enlargement. Enclosed in

its posterior walls were trachea; esophagus and numerous nerves. Posteriorly the whole was firmly attached to the vertebral column from the second to the sixth thoracic vertebra. All of these showed deep corrosion, especially the fourth, in which the body was a mere shell and the finger could be passed backward to the spinal canal. The descending aorta was to all appearance perfectly normal.

The third case was referred for possible aneurysm of the thoracic aorta. The symptoms were chiefly dyspnea and murmur of pulmonary area. The case as seen with the *x*-ray is one of aneurysm of the pulmonary artery. No blood examination was made. This condition is often associated with persistent ductus botalli.

My excuse for reporting these cases is that they (especially the first and second) present this class of immense aneurysms which from better treatment are becoming rare. We all believe these cases to be syphilitic, and on account of the great number of Negroes they are much more common in the South than in other sections of the country. Out of a good many thousand *x*-ray examinations in two years' work in the Navy I never saw one thoracic aneurysm. This, I believe, is due to the fact that there were comparatively few Negroes. There were physical examinations at short intervals, precluding the possibility of cases running to such extremes, and very few early syphilitic lesions got by without note on health record and very thorough treatment and follow-up.

FIG. 1. ANEURYSM OF ASCENDING AORTA.

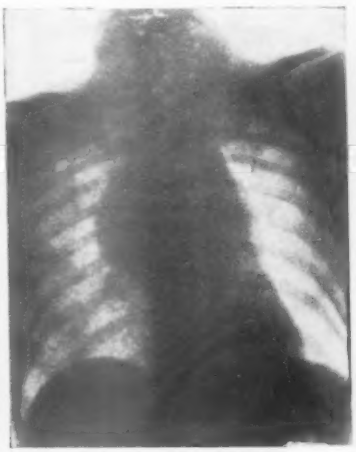

FIG. 2. LARGE DISSECTING ANEURYSM OF THORACIC AORTA.

FIG. 3. ANEURYSM OF PULMONARY.

TREATMENT OF CANCER, PARTICULARLY OF THE TONGUE, TONSIL AND RECTUM, BY BURIED EMANATION*[1]

By H. H. JANEWAY, M.D.

NEW YORK CITY

DURING the past year and a half the use of buried radium emanation has opened up in our experience at the Memorial Hospital new possibilities in the treatment of cancer by radium. For at least two years from the beginning of our experience with radium we made use of only local application of radium to surfaces of cancer. By this method the new growths were attacked from only one surface, and every device was resorted to for the purpose of obtaining complete and as uniform penetration as possible of the whole thickness of tumors. Heavy filtration was resorted to for the purpose of eliminating all but the very penetrating rays and thus obtaining not only a deep effect but one more uniform. Whenever practicable, the radium was applied at a distance from the growth, for the purpose of subjecting the surface of the growth and its deeper portions to as nearly the same dosage as possible. Every means was made use of for the purpose of evenly distributing the radiations over the surface of tumors, such as embedding the tubes in molds of the tumor made of dental modeling compound and pinning the tubes to the surface of the tumors and ulcers by little hooks, or folding rows of tubes in pleats of cotton cloth.

The results of these methods in many instances were excellent, and have been fully described in the monograph published recently from the Memorial Hospital on "Radium Therapy in Cancer." These methods are still in use in selected cases, but none of them compare with the results more recently obtained by embedding emanation, sealed in minute glass tubes, within the tumor tissue. By thus using emanation, the radiations are not only far more evenly distributed throughout the tumor but a much more intense and better localized radiation of the tumor is obtained than by other methods.

Duane deserves the credit of having first suggested this use of radium emanation. Stevenson [2] has reported 22 cases very successfully treated by this method. They include 3 cancers of the tongue, 4 of the uterus, 2 of the breast, 2 of cervical glands, 1 abdominal tumor, 2 epitheliomas of face, 1 parotid tumor, 1 of nasal cavity, 1 lymphosarcoma, 1 epithelioma of palate, 4 rodent ulcers.

We have used this method continuously during the past year at the Memorial Hospital. The radium emanation is collected in the usual manner in a long capillary tube, which is divided into minute parts by a flame, sealing the ends, as it divides the tube. These tubes measure 3 mm. × ¼ mm.

A machine for mechanically dividing these tubes has recently been constructed by Mr. Turnbull after designs by Mr. Failla. With this machine a large number of these tubes can be prepared in a very short time, and so prepared that they are more uniform in size and length than when they are divided by hand. The tubes are easily placed in the distal end of a needle which is no larger than a slender aspirating needle. The aspirating needle is then inserted within the tumor tissue and the tube is expelled by the wire stylet of the tube. By inserting other tubes in various places in the tumor, a very uniform distribution of emanation only lightly filtered is secured throughout the

[1] Radium emanation is a gas given off from radium at a constant rate. It emits all the therapeutically active radiations of radium. It and its method of collection are fully described in the book on radium therapy in cancer published from the Memorial Hospital in 1917.

[2] Stevenson, W. C. "The Theory and Technique of a New Method of Radium Therapy," with notes on cases treated during the last nine months. *Dublin J. Med. Science*, 1915, CLIX, 177.

*Read at the Third Annual Meeting of the American Radium Society, Atlantic City, N. J., June 5, 1919.

whole tumor. There are numerous advantages in this method:

1. There is very little loss of the radiations, inasmuch as the emanation is inserted within the tumor tissue and left there either permanently or until it sloughs out. Almost 100 per cent of its efficiency is directed against the tumor.

2. It is a most economical way of using radium, as small quantities will produce changes accomplished by other methods only with the use of large quantities.

3. Instead of wasting the more weakly penetrating gamma rays and the beta rays by filtration, the tumor tissue itself is made to act as a filter, and those rays, which are filtered out by other methods, particularly the beta radiations—ten times as numerous as the gamma rays, are made use of to destroy the growth.

4. A more intense radiation of the growth can be secured with greater safety and with less discomfort to the patient, because these softer gamma radiations and the far more numerous beta radiations possess a limited range of penetration around each tube as a center, and in consequence heavy dosage can be given to the tumor tissue alone with little damage to the surrounding tissues.

5. The simplicity of the method makes it not only the easiest method of exposing tumors to radium, but furnishes a way of thoroughly radiating tumors which are inaccessible to any other method of treatment, for instance, tumors of the tonsil, the pyriform sinus, or even the rectum.

All these claimed advantages have been more than substantiated in practice. To illustrate them, I have selected one or two cases from each group of carcinomas in which we have found the method especially valuable. They include two cases of cancer of the tongue; 2 cases of cancer of the tonsil; 1 case of lymphosarcoma of the tonsil; 1 case of branchiogenetic carcinoma of the neck; 1 case of advanced recurrence in the cervical lymph nodes, secondary to a carcinoma of the tongue previously and apparently successfully removed by operation; 1 case of advanced primary carcinoma of the antrum; 1 case of cancer of the rectum; 1 case of cancer of the labium minum and urethral orifice; and 1 case of cancer of the cervix uteri. Again it may be emphasized that these cases are only illustrations of others like them in each group. The method is not—as perhaps is true of all present day methods of dealing with malignant new growths—entirely devoid of danger. Two patients with suppurating growths died of sepsis; a number of patients have died of hemorrhage. However, the chance for life which many patients have is far greater when treated by this method than with any other method of using radium, and in a measure the dangers can be successfully guarded against.

Sepsis is most to be feared in feeble patients or subjects with otherwise lowered resistance who possess suppurating tumors. Hemorrhage is a very real danger and is most to be feared in the treatment of cancer of the tongue or tonsil. There is no method of successfully coping with it except by ligation of the external carotid and lingual artery in the case of cancer of the tongue, and of even the external and common carotid in cancer of the tonsil, though the necessity for this radical step is rare. The common carotid may be more safely ligated if the operation is done under local anesthesia in two stages. In the first stage the lumen of the vessel is not completely obliterated by the use of a silver wire which is replaced by another ligature in twenty-four hours' time. Comparatively few patients develop severe hemorrhage, and it is almost always safe to wait for indications that dangerous hemorrhage will take place, such as preliminary small hemorrhages, before ligating the vessels. The almost universal necessity of opening the neck for the removal of the lymph glands obviates in part the objection to ligating the large vessels, for the two procedures can be done at the same time. The liability to hemorrhage does not always bear a definite relation to the dosage employed. The most striking illustration of this was a patient who was being treated for a rather small cancer of the tonsil on January

7 and March 18, 1918. The dose employed on January 7 was only 6 mc., and on March 18, 4.5 mc. Complete healing of the lesion took place, so that the lesion was considered cured early in the summer of 1918; and yet without apparent cause or recurrence of the induration, a small area of gangrene developed in May 1919, and the man died of sudden hemorrhage two weeks later. Such accidents are very unusual. Another danger, to be less feared however, is necrosis. In

FIG. 1. EPIDERMOID CARCINOMA OF THE TONGUE, CLINICALLY CURED BY ONCE EMBEDDING EMANATION IN ITS SUBSTANCE.

strengths of tubes practical for embedding in tumor tissue 1-2 mc., there develops around each tube a sphere of necrosis. Bagg has shown that necrosis may extend through a sphere 1 cm. in diameter around a tube containing 1 mc. This necrosis develops slowly and is slowly replaced by fibrous tissue. It is largely due to the beta radiation, and inasmuch as the beta radiation is so much greater than the gamma radiation, the distance of the extent of the necrosis from the tube does not bear a relation to be expected off-hand to the strength of the tube. An excessive necrosis, or one too suddenly produced, may be accomplished with toxic symptoms. It is probably due to this cause that we have had certain bad results in the treatment of pyloric cancer by buried emanation. When embedded in thin-walled hollow viscera the necrosis around buried emanation tubes may cause perforation. Their use in the esophagus and in certain places in the stomach and intestines and near large vessels or nerve trunks unprotected by thick

FIG. 2. ADVANCED EPIDERMOID CARCINOMA OF THE TONGUE CLINICALLY CURED BY THE COMBUSTION OF SURFACE APPLICATIONS AND EMBEDDING EMANATIONS.

layers of tumor tissue is contraindicated for this reason. This danger has not, however, been encountered in the rectum, where the most gratifying results have followed the use of buried emanation. As a rule the most favorable results follow the use of the buried emanation—results such as can be obtained in no other manner. The method has made possible the successful treatment of lesions in the mouth and rectum which previously we would not have attempted to treat.

The most important factor in success by this method is the selection of the proper dose for the first treatment. At present no absolute directions for dosage can be given. Because of cross-firing the dose is proportionately less for large tumors than for small ones. At present it is dangerous to formulate rules. The appropriate dose is solely a matter of judgment developed from experience. The best guide is the dosage used in the following case reports selected to illustrate this method. We are gradually approaching a standard dosage which we hope soon to publish.

Case Histories

Two well established cases of carcinoma of the tongue clinically cured by embedded emanation.

Case 1. E. F., female, thirty-six years, applied for treatment February 4, 1919.

History.—The teeth had been in poor condition for years. Six roots had recently been removed, around which there were pus pockets. In November, 1918, an ulcer developed on the right lateral surface of the tongue which was thought to be a canker sore. Two similar ulcers developed near the tip of the tongue. These last spontaneously healed, but the first ulcer on the lateral surface of the tongue gradually increased in size.

Examination.—On the right lateral surface of the tongue, opposite the site of the molar teeth which have been removed, is an ulcer 2½ cm. in diameter. The base of this ulcer is raised ½ cm. and is covered with neoplastic nodules. There is only a shallow infiltration of the substance of the tongue beneath the base, although the lesion is bulky. (Fig. 1.) No palpable lymph nodes.

Microscopical examination.—Epidermoid carcinoma.

Treatment.—February 4, 1919. 13.1 mcs. in three small glass tubes embedded in the substance of the ulcer.

February 6, 1919. 292 mc. in four tubes of ½ mm. silver placed on the surface of the ulcer in a mold of dental modelling compound for one hour. Following the treatment the patient became more comfortable, suffering no unpleasant reaction whatever.

February 27, 1919. No evidence whatever of any disease.

Case 2. P. T., seventy years, male.

History.—Has been an immoderate smoker, usually with a pipe, for years. Edentulous for the past six years. A small ulcer developed on the right border of the tongue a year and a half ago. This ulcer has gradually increased in size and become painful.

Examination.—On the right border of the tongue, from the middle to near the tip, is an ulcer 4½ by 2½ cm. in diameter. The edges are raised and hard, and nodular. The base is hard and elevated. The infiltration of the substance of the tongue beneath the ulcer is not deep. (Fig. 2.)

Treatment.—March 27, 1918. 305 mc. in 8 tubes of ½ mm. silver, applied to the surface of the ulcer in a mold of dental modeling compound for two hours.

March 28, 1918. 9.85 mc. in three minute glass tubes embedded in the substance of the lesion. Following the treatment the ulcer healed, but an indurated plaque remained at its site.

June 3, 1918. 8.5 mc. in five minute glass tubes embedded in the substance of the residual indurated tissue. Following this treatment all induration disappeared.

June, 1919. No evidence of disease.

Case 3. Advanced carcinoma of the tonsil clinically cured by one treatment by buried emanation.

C. W., fifty-six years, male, No. 25663, applied for treatment July 19, 1918.

History.—Chews tobacco. Two months before applying for treatment noticed some stiffness in the neck and a sensation of a lump in the throat. Admits syphilitic infection, for which he has received salvarsan and mercury for the past two years.

Examination.—The right tonsil and the adjacent portion of the anterior pillar of the fauces is destroyed on its surface and infiltrated deeply by an ulcerated, hard, neoplas-

tic mass. The deep cervical lymphatics along the anterior border of the sternomastoid muscle are enlarged.

Microscopical Diagnosis.—Epidermoid carcinoma.

Treatment.—14.8 mc. in six minute glass tubes, embedded in the substance of the tumor tissue.

August 19, 1918. Much improved; ulcer healing; induration disappearing. The glands on the neck have disappeared.

November 22, 1918. Healing complete. No evidence of disease.

Case 4. Advanced recurrent lymphosarcoma of the tonsil with huge cervical metastases clinically cured by one treatment of buried emanation.

C. W., seventy years, male, No. 25297.

March 19, 1918. *History.*—Uses both tobacco and alcohol; denies syphilis. About two and a half years before applying for treatment, the left tonsil became enlarged. Finally it interfered with speech and deglutition. In six months, that is, two years ago, it was removed. Three months after this operation he again noticed discomfort in the throat, which increased. Six months ago the lymph nodes in the right side of the neck became enlarged.

Examination.—Both tonsils form spherical smooth masses of approximately 3 x 4 cm. in diameter. They touch each other in the middle line and almost completely block the entrance into the pharynx. The cervical lymph glands on the left side of the neck are enlarged, forming a nodular mass 10 cm. in diameter at the base and filling the space between the body of the lower jaw to one inch above the clavicle. There is only a small node, the size of a pea, present on the right side of the neck. No enlarged lymphatics in the axillae.

Treatment.—March 27, 1918. 12 mc. in four minute glass tubes embedded in the substance of the tonsil. 10.55 mc. in four tubes embedded in the substance of the lymphatic tumor of the neck.

A very rapid retrogression of all tumor tissue followed this treatment.

April 8, 1918. Practically no remnants of the original disease left, either in the throat or neck.

December 20, 1918. He has remained free from disease to date. (June, 1919.)

Case 5. Advanced branchiogenic carcinoma of the neck clinically cured by buried emanation.

S. G., forty-six years, male, No. 25113.

History.—About one year ago a swelling on the right side of the neck was noticed. Very distinct swelling was present five months ago. On January 5th, the neck was opened under the impression that the mass was inflammatory. Very little fluid evacuated, and a piece removed for microscopical diagnosis demonstrated the growth to be an epidermoid carcinoma of most probably branchiogenic origin.

Examination on admission.—The right lateral surface of the neck is the seat of a large discoid swelling 9 x 9 cm. extending from the ear to the clavicle. The tumor is very hard. Over the middle of the anterior aspect of the tumor mass is a discharging sinus, 1 x 3 cm., which leads into a deeply excavated cavity.

Treatment.—January 10, 1918. 1049 mc. filtered through 2 mm. lead and placed over the tumor at a distance of 10 cm. for 18 hours.

January 12, 1918. 49 mc. in small glass tubes embedded in the mass.

February 11, 1918. Tumor less than half the original size.

March 25, 1918. Tumor has practically disappeared.

March 27, 1918. Small nodule on the lower portion of the neck removed. This showed epithelioma. No evidence of any return of the disease to date. (June, 1919.)

Case 6. Large metastatic tumor of the neck, secondary to primary carcinoma of the tongue, reduced to a small cystic mass by combined surface application and buried emanation.

P. H. G., fifty years, male, No. 26101.

History.—Denies syphilis. In April, 1917, noticed a small ulcer on the right border of the tongue opposite the first molar tooth. This caused very little trouble until the

early part of 1918 when it became painful and made swallowing and speaking difficult. In April, 1918, the involved portion of the tongue was resected, and the glands on both sides of the neck were removed by Dr. John Erdmann. The resection of the tongue was done by cautery. Subsequently a collection of pus was evacuated from the right submaxillary space. The neck from the floor of the mouth to near the clavicle is filled by a large, hard, confluent mass. Sinus opens at the base of the mass and is 1½ inches in length.

Treatment.—Before coming under our care, he received inefficient radium treatment which produced some temporary improvement. He was admitted under our care February 4, 1919. At that time he had a hemispherical mass almost completely filling the right side of the neck. The patient was in severe pain.

Treatment.—February 5, 1919. 30 mc. embedded in minute glass tubes within the substance of the tumor.

February 6, 1919. 1546 mc., filtered through 2 mm. lead, placed over the surface of the tumor for 6½ hours at a distance of 6 cm.

February 17, 1919. Definite diminution of the pain. The tumor in the neck is softer.

March 7, 1919. Very much improved.

May 2, 1919. Tumor in the neck is about one-fourth of its original size, and is cystic. Patient absolutely comfortable. No recurrence within the mouth.

Case 7. Primary carcinoma of the antrum clinically cured by one treatment of unfiltered radium.

L. S., fifty-nine years, female, No. 25687.

History.—Patient has been frequently ill with "sore throat." Eight weeks ago noticed a disagreeable sensation in her right eye and first became aware that the right cheek and eye were swollen. This swelling has gradually increased.

Examination.—The right cheek is swollen. The right eye is inflamed and bloodshot. Epiphora is present. Within the mouth the superior alveolar process on the right side is swollen as if displaced downwards by distention of the antrum. In the bucco-gingival groove there protrudes a small ulcerated mass which is breaking through from the cavity of the antrum at this place.

Microscopical examination.—Epithelioma of the antrum.

Treatment.—July 29, 1918. Under local anesthesia the external carotid was ligated on both sides of the neck and the right antral cavity was opened by removing the superior alveolar process; 50 mc., unfiltered in glass tubes, placed in the center of the antrum and surrounded with packing; left in place forty-eight hours.

Following a period of radium inflammation and a lobar pneumonia, the patient made a good recovery, and on September 30 there was no evidence of disease present.

May 2, 1919. Still no evidence of disease present.

Case 8. Carcinoma of the rectum clinically cured by a combination of surface treatment and embedding of emanation.

M. J. R., female, forty-nine years, No. 29201, applied for treatment February 27, 1917. For the year past the patient had bleeding from the rectum. There also had been—particularly more recently—some discharge from the bowels between the bleeding. Six months ago the sensation of a foreign body in the rectum began to be felt. Two months ago constipation became very troublesome and defecation painful.

Examination.—Upon the anterior wall of the rectum is an ulcerated growth, 3 cm. in diameter. The edges are prominent and hard and nodular. The base is broad and somewhat excavated. The growth involves only one-half of the circumference of the rectum, but the wall is infiltrated to a considerable depth, forming a prominence easily felt through the posterior vaginal wall.

Microscopical examination.—Plexiform epidermoid carcinoma infiltrating the mucosa, apparently arising from cylindrical cells of the surface mucosa.

Treatment.—March 1, 1917; 364 mc. in 14 tubes of 1 mm. platinum covered with rubber and arranged in pleats of cotton

cloth, placed over the lesion and retained in place for two hours by packing, which also served to separate the opposite rectal wall.

March 2, 1917; 297 mc. in 27 platinum tubes, placed on the posterior vaginal wall over the anterior surface of the tumor for one hour. Following this treatment a rapid retrogression took place.

May 20, 1917. There was no evidence of disease.

November 10, 1917. A small isolated nodule had developed in the anterior wall of the rectum. This was removed by excision, and 45 mc. of radium in ½ mm. of silver embedded in the wound for two hours.

January 2, 1918. Recurrence of a small mass in the anterior wall of the rectum. Ten mc. in two minute glass tubes were embedded in the substance of the mass.

Following a period of discomfort, there was a complete disappearance of the mass and on April 9, 1918, a digital and proctoscopic examination under an anesthetic failed to reveal the presence of disease.

On May 9, 1919, a digital examination failed to reveal the presence of any abnormality in the rectum, and the patient was perfectly comfortable.

Case 9. Advanced carcinoma of the clitoris, urethral orifice, and anterior vaginal wall, with metastatic nodule in posterior vaginal wall, clinically cured by once embedding emanation in each mass.

J. H., forty-two years, female, No. 25283, applied for treatment March 12, 1918.

History.—Diphtheria twelve years ago. Large fibroid removed from the uterus eight years ago. Three months before application for treatment, she noticed a slight vaginal discharge, which at first was intermittent and later became continuous. Four months before treatment here, a soreness in the labia minora was noticed. Six weeks ago micturition became decidedly painful, and these symptoms have increased slightly up to the present time.

Examination.—Surrounding the urethral meatus and destroying the anterior two-thirds of the right labium minum is an ulcer 2½ cm. in diameter, with an indurated base and papillary surface. The anterior border involves the clitoris. The induration of its base is deep-seated and extends 2 cm. upward into the anterior vaginal wall.

Microscopical diagnosis.—Epithelioma of the right labium minum.

Treatment.—March 14, 1918. 11.3 mc. in five minute glass tubes embedded in the substance of the tumor; also 152 mc. in five glass tubes enclosed in ½ mm. silver, applied to the surface of the tumor in a mold of dental modeling compound.

July 2, 1918; 15 mc. in twelve minute glass tubes embedded in the substance of the tumor.

Following the first two treatments, the lesion showed a gradual improvement until July, when the ulceration was almost healed, but considerable induration remained. Following treatment in July improvement continued until January 2, 1919, when the evidence of her disease may be said to have disappeared with the exception of a small pea-sized nodule of doubtful significance in the posterior right labium. Fearing this to be a metastasis, she was treated again on January 16, 1919, 7.8 mc. in two minute glass tubes embedded beneath the nodule.

May 2, 1919. Nodule has disappeared and ulceration caused by the treatment has healed.

Case 10. Advanced uterine cervical cancer clinically cured by local application within the cervix and embedding of emanation within the tumor tissue.

G. S., female, thirty-four years, No. 25431, applied for treatment May 1, 1918.

History.—No previous illness. Menstruation regular and normal. Two children, 13 and 14 years of age. Births not difficult and no instruments used. Three or four months before applying for treatment, first noticed bleeding from vagina. This gradually increased up to the present time. Her physician first advised operation, but after having observed the condition for four weeks he referred her to us for treatment.

Examination.—The anterior lip of the cervix is completely replaced by a large fungating papillary mass, 5 cm. in diameter and completely filling the vault of the vagina. It bleeds on the slightest trauma and infiltrates the mucosa as far as the vaginal walls. The uterus is movable, but uncertain whether broad ligaments are infiltrated. The condition is inoperable.

Microscopical examination.—Papillary plexiform epithelioma.

Treatment.—May 1, 1918; 19.1 mc. in seven minute glass tubes embedded in the tumor tissue; also 191.9 mc. in three tubes of 1 mm. platinum covered with rubber inserted into the uterocervical canal for fifteen hours.

Following the treatment, there was a rapid retrogression of the tumor mass, which appeared to be complete on August 19, 1918.

May 1, 1919. No evidence of disease.

Case 11. Advanced carcinoma of nasopharynx infiltrating the soft palate and tonsil, with large metastases in the lymph nodes on both sides of the neck.

C. D., sixty years, male, applied for treatment on February 8, 1919.

History.—He has had nasal catarrh for years. Nose was broken in a severe trauma many years ago. Operated on for ulcer of the stomach in April, 1917. Two years ago a swelling developed in the lymphatic glands of the neck. In June, 1917, he developed a laryngeal voice, tinnitus, and nasal obstruction. He received treatment from a number of specialists. Finally a specimen was removed and the diagnosis of carcinoma established.

Examination.—The nasopharynx is filled by a large neoplastic mass which seems to be growing from the right side. It involves the soft palate, the posterior pillar of the fauces, and the tonsil of the right side. Large nodular fixed masses, several inches in diameter, fill the neck on each side.

Microscopical examination.—Epidermoid carcinoma.

February 8, 1919; 1979 mc. filtered through 2 mm. of lead were applied at a distance of 6 cm. for 5¼ hours to each side of the neck.

February 17, 1919; 25 mc. of emanation in five minute glass tubes were embedded in the left side of the neck; 20 mc. in four minute glass tubes were embedded in the right side of the neck; and 12 mc. in three minute glass tubes were embedded in the naso-pharyngeal mass.

March 28, 1919. Inside the mouth the retrogression appears to be complete. The inelastic tumors in the neck are reduced to one-fourth their original size. The nodule in in the right side of the neck is now 2 x 4 cm. in diameter at its base, and that on the left side 2 x 2 cm.

Treatment, continued.—April 19, 1919. 7.1 mc. in five minute glass tubes embedded in the mass remaining on the right side of the neck; and 7.5 mc. in five minute glass tubes embedded in the mass on the left side of the neck.

It is impossible to give a just idea of the improvement and what it meant to the patient by a mere recital of the clinical findings before and after treatment. His physician, Dr. Farrell of Utica, who was kind enough to refer this patient to us, wrote us on April 3rd: "I am perfectly astonished and delighted with the change for the better in the condition of this patient's neck and throat. This is the first positive result I have seen from the use of radium." The right side of the neck has lost its hard infiltrated feeling and is soft and pliant. The gland on the left side is diminished from the size of an egg to the size of a nut. The growth in the naso-pharynx has melted away until only a small remnant remains in the vault.

DISCUSSION

Dr. C. H. Viol, Pittsburgh.—I regret that the illness of Dr. Simpson makes it impossible for him to discuss this paper, since I would prefer to consider only the physical side of the subject. The good reports which Dr. Janeway makes are cause for congratulation and they are in line with what we may anticipate from

the work at the Memorial Hospital where so much radium is available.

I would like to reiterate several points which Dr. Janeway has made. First, it seems to me that the advantages which are attained by the use of the emanation needles inserted into growths, may be in part attained by the insertion of needles containing the actual radium salt. In each case there is the advantage that all the radiation is brought to bear on the malignant tissue, whereas in the application of radium from without, since it is not possible to reflect the gamma rays, less than one half of the radiation strikes the malignant growth, and frequently the radiations which do not strike the growth do cause damage by their action on adjacent normal tissues. In the case of radium needles, which usually consist of a metal container, there is less beta ray action about the needle than is produced by the emanation needles which consist essentially of tiny glass tubes, and it seems to me that this is a point of some importance which will require further observation before we may know definitely whether the necrosis produced by the intense beta ray action from the emanation needles can be considered as a negligible effect.

Dr. Hugh J. Young, Baltimore.—I am very sorry that Dr. Janeway did not make his paper longer. What we need are the cases; there is too much going back into the history, and if they would give us the details it would be very helpful. The most important scientific productions are the ones which give details. The reason that Israel's book on the kidneys is so great is because he gives us details of every case. My interest in the use of radium has been largely in its use in carcinoma of the prostate, seminal vesicles, and bladder. I am very sorry that Dr. Janeway did not bring up that subject, because I know he has had much experience. We started about four years ago with a modified cystoscope to apply radium direct into the bladder, with little or no screen, and we have had remarkable results. In order to get the radium just where we wished to have it, we used a clamp and the operator looking in could see just where he wanted it and left it there. We uniformly left 200 or 250 mg. buried in the mass, leaving it for an hour, and that practically approximates your method of the needle. I think the needle is a little better because we have a little screening with our methods.

Also with the use of radium in the rectum I think the great trouble has been that the instrument used was not firm enough to place the radium just where it was desirable. Recently in London I saw the radium simply placed inside and the operator did not have any idea whether it was on the posterior or rectal wall. With the gloved finger it is perfectly easy to put the radium anywhere you wish in the rectum, and by clamping it there you know where it is. We have avoided necrosis by not putting the radium in the same place frequently. We have applied one hundred mg. twenty-five times, an hour each time, without producing necrosis. We would run up and down the seminal vesicle, and up and down the prostate, and up and down the other seminal vesicle, and never get necrosis, because we were careful not to put it back in the same place; and to be sure of this we made a chart upon which we put down each time where we made the application. We did not use any screen whatever except for a little silver and no rubber at all.

I rather agree with Dr. Clark that probably a lot of the rectal irritation has been due to the examination and not to the radium.

In regard to the other bladder cases where we were not able to use the emanation, by plunging the radium into the mass and then employing fulguration, much as Dr. Pfahler has employed the method, we have found this very effective in large tumors of the bladder. Whether they are actual carcinoma or not, it is impossible to say, but they are unquestionably cases that would have become malignant. The use of fulguration is of very distinct value in supplementing radium. The two work together very well, and the electricity added to the rays is certainly a very valuable adjunct. I believe instruments can be easily constructed by which emanations can be placed in the tumor and not taken out until the tumor is removed. I have had some made very small, which the patient might easily pass out through the urethra. I think it would be easy to bury a lot of these in the tumor and then let the patient void them afterwards.

Dr. W. L. Clark, Philadelphia.—Mr. Chairman: I have heard no remarks on laryngeal cancer, but I have used radium recently in some cases which have been the cause of a great deal of worry. I have used the electrothermic method, but the result was not good; but by using radium we are much encouraged. A tracheotomy is always done as a preliminary

procedure; and about a week or ten days afterwards the larynx and tongue reflexes are destroyed by cocain, the patient is given morphin, five needles are introduced in a brass receptacle covered with rubber, and the patient's reflexes being destroyed and the patient made comfortable by the morphin, the needles are placed in position and kept in for six hours. In one case the breathing was very labored and examination revealed an extensive growth in the larynx. He first took three massive doses on the outside followed by the radium inside. The man returned in three weeks very much improved, the growth very much lessened, and we have him another treatment at that time.I saw him a short time ago and there is apparently no malignant tissue left. He has gained considerably in weight.

About the hemorrhage in tonsil work, I have used radium in tonsil cases a great deal, sometimes supplemented by the electro-thermic method. We had one fatal hemorrhage about the fifteenth day. We have not had many, some slight ones, but this perhaps has been more good luck than good management. Here is the procedure we have adopted. If the external carotid was ligated at the time of the operation, or if we expected sloughing out from the use of the radium, the collateral circulation would be established and we would get our slough anyway; but our practice now is to wait ten days, for it will not bleed until the slough comes away. Further, the organization will have taken place, and if we do the ligation then we believe the hemorrhage will be less likely than if we do the ligation at the time of the operation.

Dr. D. T. Quigley, Omaha.—I think we do not need to go to so much trouble as Dr. Clark does in getting at the larynx. In a tubercular case treated recently we simply sat the patient down, put some seven per cent cocain into the larynx, and put 60 mg. of the element covered with thin rubber into the larynx. The bulk is not large enough to obstruct breathing and the patiently usually has a two-hour dose each time. At the first treatment the patient cannot stand the thing in the larynx very long at a time. These patients sit up; they do not lie down at all. They can only stand the tube in for about ten minutes the first time and then cough up the tube, but it can be replaced in a few minutes. The radium is kept in by having the wire well wound with adhesive tape and he bites on it. After it is in the larynx, we take an *x*-ray picture to see that it is in the proper place. Another way is to put a piece of Wilemite over the place in a darkened room. The second time we find that they can hold it about twenty minutes, the third day half an hour, and after that they can keep it in place for two hours, and we then give them a two hour treatment whenever they need it. We figure on keeping this up until the case is cured. I have found that the larynx will stand as large a dose as the skin, and we have no trouble with edema of the larynx.

In the application of radium in the rectum, at first we had a good deal of trouble in holding the thing where we wanted it in the rectum. I presented to the Society last year a thing that I suppose most of you have forgotten, and I will tell you about it again. Place the radium on the handle of a dessert spoon—you can feel just where you are putting it, bend the bowl of the spoon around so that it lies on the buttocks or on the back. It will stay where it is put and there is no trouble about holding it in place. This method is also successful in holding the radium in the mouth and in the throat, as I explained last year.

Dr. Albert Soiland, Los Angeles.—I came here this morning full of pep and enthusiasm. I was the possessor of 200 mg. radium element, and nearly bursting with pride and self-consciousness. Now the scene suddenly changes. Dr. Janeway has spoken, and the verdict is radium emanation. This means $100,000 plus. I am turning my face west and homeward, a sadder but wiser man.

Dr. Henry H. Janeway, New York.—We have used buried emanation very successfully in the rectum and also in the bladder. I have been able to bury emanation tubes in the bladder. The tubes are very small, only one-fourth mm. in diameter and 3 mm. long, and the needle by which they are introduced is so slender that it will go through the catheter tube of a catheterizing cystoscope and so flexible that it can be bent up at an angle by the bridge of the cystoscope and thus introduced into the tumor. The subject is so broad that I cannot take it up fully.

I do not think it is necesary for Dr. Soiland to throw away his 200 mg. of radium. He can do successful emanation work with that amount but more successful work with 250 mg. of radium, and you will find that the use of the emanation will probably enable you to do more work.

FURTHER COMMENTS ON RADIO-ACTIVITY*

By ALBERT SOILAND, M.D.

Fellow American College of Physicians, Prof. Roentgenology College of Physicians and Surgeons, University of Southern California.

LOS ANGELES, CALIF.

SINCE the last meeting of this Society, at which time the writer was permitted to present an article on the physics of radium and roentgen rays, he has made an effort to elaborate on these subjects in order to bridge the chasm which unfortunately exists between the radium therapist and the roentgenologist. In order to arrive at some medium ground for comparison, a few photographic experiments have been carried out which will serve to illustrate the text and which will be presented in the shape of lantern slides at this meeting.

To make a comparative study between radium and roentgen rays, one must approach the subject without a vestige of bias. It is only too true that the out and out roentgenologist frequently belittles and sometimes maligns radium. The writer has also heard radium therapists say many unkind things about the roentgen rays. It frequently happens that a roentgen operator with a most complete and efficient installation will deny any virtue whatsoever to radium, largely because he has been unable himself to secure any results from the small radium capsule he bought in Paris or Vienna fifteen years ago. Again, we have seen Radium Institutes in which an almost unlimited amount of this precious element was available, where upon a dusty shelf could be seen a little old one-cylinder *x*-ray machine, which from time to time was aimed at a patient; and it is safe to say that no human being could even guess, much less scientifically determine, just what sort of an *x*-ray was being ground out.

There is no need to extol before a scientific body such as this the virtues of radium; yet the sum total of success or failure with this potent element depends in a very large measure upon an intelligent conception of the laws of radio-activity coupled with a basic knowledge of human pathology. The same is, of course, true with roentgenology.

In the present attempt at a comparison of the two agents, the writer craves the indulgence of the audience if some of this is ancient history to you. The matter, however, will be covered as briefly as is consistent with an intelligent presentation.

To make a comparative rating between a single massive roentgen exposure and a single one with radium would involve many factors and render such a task exceedingly difficult. In a functionating *x*-ray tube, we have a potential source of radiant energy, much greater than in any given quantity of radium available for therapeutics. To establish a standard technic under such conditions, one would be compelled to reduce the *x*-ray output in an individual unit to a degree that would correspond to a standard radium equivalent. The next step would be to use suitable filters to insure radiation of the same wave length and frequency for both agents. Then if the time element of exposure could be harmonized, it would make absolutely no difference which agent was employed. In such an exposure with either agent, the tissue changes would be exactly alike, both clinically and microscopically.

At present, a standardization as just outlined is impossible, and we shall have to confine ourselves to discuss radium in the amounts usually available for practical work. Outside of a half dozen large Eastern institutions, this would range from 100 to 200 milligrams element.

In roentgen therapeutics, the ordinary setup of a Coolidge tube, working on 100 K.V. pressure, with 5 m.a., at an 8 inch skin distance without filter, will produce an intensive erythema or surface reaction sufficient to destroy a superficial epithelioma in a single five-minute application. As even this short exposure has been found to produce

*Read at the Third Annual Meeting of the American Radium Society, Atlantic City, N. J., June 5, 1919.

lasting *x*-ray dermatitis in susceptible individuals, such an application is undesirable in skin work, so this dose is normally used for its deep effect on underlying tissues, employing opaque filters to screen out the rays that produce the surface irritation.

To obtain the same action as just outlined with say 100 milligrams of radium, we would have to apply this element or emanation for several hours over the skin to get the therapeutic effect; and if we desire a deep effect, heavy filters would be necessary to cut out the preponderant radium beta or short range rays, and then an exposure of a great many hours would be necessary to permit the gamma rays to functionate in a manner equal to the five-minute *x*-ray exposure already noted.

FIG. 1. ROENTGENOGRAM OF HAND, MADE AT 40 FT. FOCAL DISTANCE. 100 K.V., 6 INCH BACK UP. 40 MILLIAMPERES. 10 SECONDS EXPOSURE.

Bearing this in mind, and recalling that radium's greatest source of energy lies in its preponderance of beta radiation or short range rays, it is easy to understand why a radium dermatitis is more evanescent than a roentgen dermatitis. A radium dermatitis is just like an intense solar erythema. It appears quickly, is quite superficial, hence heals readily. Exactly the same sequence

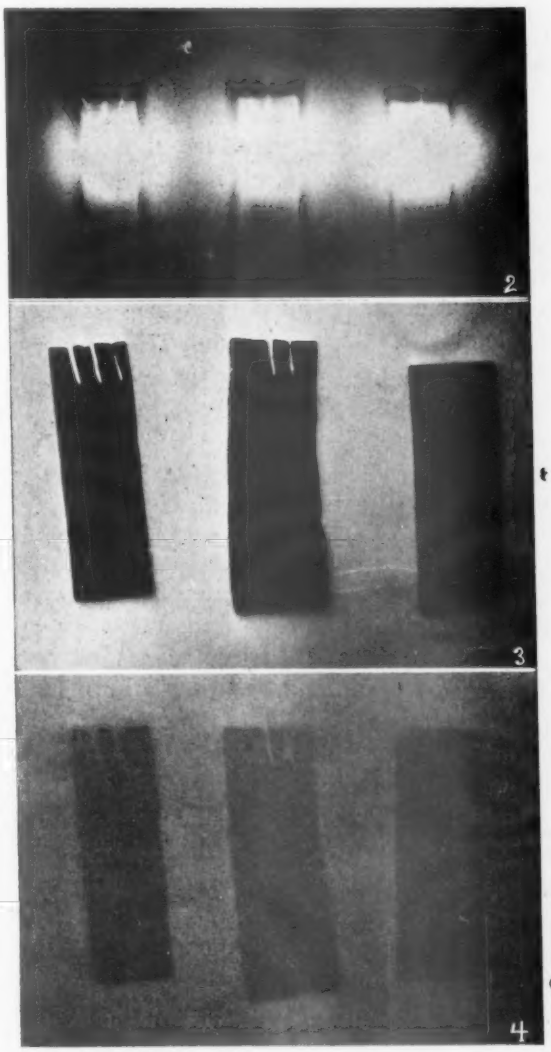

FIG. 2. THREE TUBES RADIUM ELEMENT, 25 MILLIGRAMS EACH, CONTAINED IN ORIGINAL SILVER TUBE, NO OTHER FILTER, PLACED OVER LEAD STRIPS ONE, TWO AND THREE MILLIMETERS THICK, RESPECTIVELY. ALL PLACED ON LIGHT PROOF PHOTOGRAPHIC NEGATIVE. EXPOSURE ONE HOUR. Note limit of visible radio-activity, also actinic shadows and secondary ray effects.

FIG. 3. LEAD STRIPS PLACED ON NEGATIVE UNDERNEATH PATIENT. *X*-RAY EXPOSURE OF 25 MILLIAMPERE MINUTES WITH COOLIDGE TUBE, SO CALLED ERYTHEMA DOSE APPLIED TO SURFACE. Note intensive reduction of silver on negative not covered by lead, also clear cut shadows of these.

FIG. 4. LEAD STRIPS PLACED ON NEGATIVE UNDERNEATH PATIENT. EXPOSURE THROUGH BODY. ONE HUNDRED MILLIGRAM HOURS RADIUM ELEMENT. Note incomplete actinic action on plate emulsion, and rather dull shadows of lead plates, the latter due to secondary ray effects in the lead.

would follow an exposure by a so-called soft *x*-ray tube working under low voltage.

In this example, the *x*-radiation produced would resemble the usual radium beta radiation. Photographically, the foregoing statements can be readily demonstrated. At a 48 inch distance from the plate, 150 milligrams of radium, exposure five minutes, produces no demonstrable chemical change in the emulsion. This demonstrates that no appreciable beta radiation reaches the plate, and that the gamma rays pass through the emulsion sensibly unchanged. Placing strips of lead on plate and repeating experiment, but increasing time to ten minutes, shows a slight fogging of the emulsion due to the induced radio-activity in the lead strips. The same experiment carried to one-half hour's exposure with a fresh plate shows the shadows more clearly.

Performing the same experiment with an *x*-ray exposure at the same distance, the emulsion of the plate is blackened with the shortest exposure we can make, viz., one-sixtieth of a second. With radium (200 mg.), distance 10 feet, no image was obtained by either primary or secondary rays in one hour's exposure.

In order to ascertain the distance at which a serviceable *x*-ray plate could be made with an ordinary exposure, we rigged up a tube and plate to get the greatest space possible in our laboratory. This measured 40 feet from anode to negative. An exposure of 10 seconds, 50 milliamperes, on a 6 inch back-up, gave us a serviceable plate, that is, where bone detail can readily be seen, attention being directed to the fact that the total *x*-ray energy used was quite ordinary in amount. The photographic experiments were made under working conditions as nearly alike as possible. Thus the average amount of radium used at an ordinary treatment rarely exceeds 100 milligrams element, and for all the plates made at working distance, this amount is used. In the long range exposures, 150 and 200 milligrams element are employed. The *x*-ray plates were made with the regular standard Coolidge tube settings.

Photographically, it is almost impossible to demonstrate the difference between the dermatitis produced by *x*-rays and that from radium. This is due to the inability of the sensitive emulsion to register ordinary color changes.

Every competent roentgenologist and radium therapist can show slides and give case records of a great many lesions cured; therefore no time will be consumed in an elaboration of this kind now. It would be of considerable value, however, to know how many failures would ensue out of a certain number of like conditions treated by both roentgen and radium therapy. The test then becomes one of personal ability, for with ample radium one can duplicate the effects of roentgenization and vice versa.

The writer believes that the *x*-rays offer decided advantages in the treatment of lesions covered by, or affecting, the epithelium. On mucous membranes or in cavities where soft tissues predominate, radium becomes the element of choice. This is particularly true in lesions involving the mouth and upper respiratory tract, the vagina, uterus, and rectum.

In conclusion, from an abundant practical and clinical experience with both roentgen and radium radiation and with a fairly well balanced conception of the limitations of each of these potent agents, the best results in general are obtained by a judicious combination of both.

DISCUSSION

Dr. Douglas Quick, New York.—I do not know that I can add much to the discussion except to compliment Dr. Soiland on the very excellent paper he has given us. I think he hit a very good note when he spoke of bridging the gap between the *x*-rays and radium. Unless the operator has a very large quantity of radium and a very good working *x*-ray apparatus I do not see how he can correlate them at all, but if it is worked out along those lines I think we shall get along better therapeutically and have less and less misunderstanding than at present. Correlating the action of radium and *x*-ray is a very great subject. Have you made any comparison of filters? I presume that the *x*-rays are unfiltered and that radium is filtered

up to a certain point. [Dr. Soiland said the glass was 1½ mm. 6.] I think the results are most interesting as showing that the skin effect is not the same. On the other hand, it gives us a loophole of which, from a technical standpoint, we can take advantage through treatment. Frequently we find someone who will use *x*-rays and radium equally, using the application to a different part, whereas both applications are valuable if we can apply them. At the Memorial Hospital we have used the two methods and prefer the radium where we can get at a localized bulky mass, supplementing that with *x*-rays over the regional glands as far as possible. It is possible in these bulky masses to imbed radium emanation tubes that will produce radiation in all directions, by which you get the diffuse effects of the radium deep throughout the tumor and are also able to apply the *x*-rays over the surface, so that you get the rays from the front door and the back door and have the effect from both. I think we can use Dr. Soiland's findings to good advantage. We like to use the radium wherever possible on the localized and bulky lesions and supplement it as far as possible with the deep roentgen therapy.

Dr. C. H. Viol, Pittsburgh.—Several years ago it was my opinion that the radium effect on tissues was quite different from the *x*-ray effect, and I recall my astonishment in talking with Professor Millikan of Chicago, when he said that theoretically the effect of these radiations on tissues should be very much the same. Due to the differences which we observe, for example, in burns from radium and from *x*-rays, I was inclined to doubt his statement; but thinking the matter over in the light of what little we know regarding the action of the rays and the nature of the burns which they produce, it seems that we must go back to the opinion that these rays differ rather in a qualitative than in a quantitative way. Beta rays do not penetrate far and consequently are likely to produce circumscribed superficial burns, which, as we all know, heal fairly rapidly, this type of burn being the one most frequently encountered in working with radium. When using the *x*-ray we have in effect a very soft gamma radiation, capable of producing burns to a greater depth than in the case of the beta rays, and burns not infrequently involving a considerable area of tissue. Under these circumstances, with a considerable involvement of tissue, repair is likely to be slow, and with the peripheral nerve terminals involved, the lesions will be painful. In the case of a gamma ray burn from radium, due to very serious overdosage in the application of radium, the effect will involve a considerable depth of tissue and may or may not be circumscribed as to the area involved. Such burns are very slow in healing and exceedingly painful, but fortunately are of rare occurrence. I have known of one such burn in my experience at Pittsburgh, and this has persisted for a number of years and has so far resisted all treatment.

With these points in mind it seems to me that the argument about the difference in burns is really no sound argument at all, and the difference in therapeutic results between *x*-rays and gamma rays can as well be accounted for by the difference in modes of applications, etc., assuming that the effects of the rays are qualitively of the same nature, as by the assumption which many prefer, namely, that rays are inherently different in their action. In the *x*-ray we have enormous amounts of energy in the form of radiations less penetrating than the gamma rays. Dr. Soiland's picture, taken 40 feet from the tube, shows this plainly, and consequently great care must be taken in using the *x*-ray, to control the enormous energy which comes into play and which is capable of producing such bad effects when improperly applied. The action of radium is essentially local, so that when employed in a malignant growth it exercises its main effect in the malignant tissue, and the surrounding tissue is less likely to be affected, due to the falling off in the concentration of the rays. A few centimeters make an enormous difference so far as the concentration of the radium rays is concerned. All of this leads me to believe that as time goes on we shall come more and more to the conclusion that the action of the *x*-rays and gamma rays is qualitatively the same but quantitatively different, due to the difference in penetration of the types of rays and the limitations of the technique in applying these forms of radiant energy.

Dr. Isaac Levin, New York.—I do not think that the the difference in the action of the radium and *x*-rays on a photographic plate offers any criterion as to their respective biological action. Biologically there is a qualitative difference not only between radium and *x*-rays, but as my recent experiments have shown, be-

tween different kinds of *x*-rays. The white blood cells are the most sensitive of any animal tissue to the action of *x*-rays. I did, in cooperation with M. Levnie, a series of experiments with the turtle, which has about 90 per cent of lymphocytes, and only 7 to 10 per cent polymorphonuclears. When two turtles are placed one on top of the other, and *x*-rayed simultaneuosly, then as a result of the treatment in the upper animal the lymphocytes are reduced from over 90 to 19 per cent, and in the lower from over 90 to about 50. In another series of experiments there was placed instead of the upper turtle a layer of meat or a dead turtle. In this series the destruction of the lymphocytes in the turtle was equal to the amount in the upper turtle of the first series. I can conceive of only one explanation of the results: The particular type of the rays which destroyed the lymphocytes of the upper turtle is absorbed by the cells and there is not enough left to act on the lymphocytes of the lower turtle.

The dead turtle, or a layer of meat, does not absorb any of this particular type of rays, and the whole amount acts on the only living turtle of this series of experiments. The same has been shown by physicists to be true in regard to the action of *x*-rays on various metals. There is ample evidence in radiotherapy that the so called "soft rays" act differently from the hard rays. A burn is much more readily produced by soft rays than by hard ones. A pencil of rays consists of different types of rays, from softest to hardest. The harder the latter the more types of rays can be obtained, and therefore the better would be the selective therapeutic results. I recently devised an *x*-ray machine by the aid of which I believe harder rays may be obtained for therapy than with the coil or an ordinary interrupterless machine. The particulars will be reported in the near future.

Dr. C. H. Viol.—So far as I know from the physical aspect there is nothing to indicate selective absorption of the gamma rays in the manner mentioned by Dr. Levin. Absorption of such short length radium as *x*-rays and gamma rays is bound up with the atomic nature of the absorbing substances rather than with the molecular structure, and since the tissues involved would have the same atomic constituents when dead as when alive, I cannot comprehend Dr. Levin's observations in turtles. Since this single experiment stands in opposition to other physical evidence I should be inclined to withhold judgment on Dr. Levin's experiment unless repetition might confirm the results. I am not convinced that his observed results might not be due to differences in the technique rather than to the selective absorption.

Dr. Albert Soiland, Los Angeles.—I want to thank Dr. Quick and the other gentlemen for their kindly and frank discussions. We are working somewhat at a disadvantage out in my country, owing to our great distance from medical centers, and hard experience becomes our main teacher. We cannot quickly summon council and compare notes, as you Eastern men can. I have been doing active roentgenology and some radium work for nineteen years, and one of my early cases of epithelioma of the lip treated with radium has remained well for fifteen years. That is to show you that I have had some experience, and am not altogether a tyro in this work. I cannot well compete in discussion of radio-physics with such men as Dr. Viol, who have every convenience at their disposal for physical, clinical, and biological experiments. I believe there is no difference between the *x*-rays and radium provided you speak of these two in the same wave length and frequency, but that is something that the average radiologist rarely does. The roentgenotherapist has a much harder thing to deal with than the radium operator. The *x*-rays change and vary in intensity all the time and can hardly be standardized, while the radium man has an apparatus which delivers a certain amount of ray energy of definite strength all the time. When the *x*-ray man learns more about stabilizing his wave forces, and the radium man learns a little more about the effects of his own agent, result will be accomplished which are at present impossible.

THE TECHNIC OF RADIUM APPLICATION IN CATARACTS

By ISAAC LEVIN, M.D.

NEW YORK CITY

IN a paper entitled "The Action of Radium on Cataracts," presented by Martin Cohen and Isaac Levin at the Ophthalmological Section of the American Medical Association on June 12, 1919, it was indicated that in incipent cataracts the lenticular opacifications may become diminished under the influence of radium. Should a cataractous lens become matured subsequent to radium treatment and should an operation then be required, no technical difficulties will present themselves. It was also proven by the authors that the application of radium is harmless to the normal tissues of the eye. In view of these results it is probable that before long many radium therapeutists will be called upon to treat cases of incipient cataracts with radium. In order to form a true estimate of the value of this method of treatment, it is imperative that a correct and uniform technic be developed.

The first requisite for the correct handling of the cases is the constant cooperation of an ophthalmologist. The latter has to make a correct diagnosis and decide whether the case is suitable for radium therapy. Furthermore, the ophthalmologist has to examine before the beginning of the treatment the visual acuity of the patient and make accurate drawings of the lenticular opacities and of the fundus details. Then at stated intervals these ophthalmological investigations should be repeated throughout the course of the treatment.

As to the technic of the radium application *per se*, one must obtain an idea of the aim to be accomplished in order to conceive the correct method. The capsular epithelium is most probably the starting point of cataract. The precipitation of the soluble ingredients within the lens which result in the formation of the opacifications cannot take place without a change in the structure of the capsule which acts as a barrier membrane. Since the capsule is a product of cell life, the change in this barrier membrane must be due in the ultimate analysis to an abnormality, in either the structure or the functions of the capsular epithelium.

It is proven biologically and clinically that the hardest beta and mainly the gamma rays of radium exert a selective action on abnormal cells. In tumors and granulomata, the action of the rays consists in the inhibition of the proliferating capacity of the cells; in conditions like Graves' disease, it influences and alters the functions of the cell. It is *a priori* possible that the radium rays may alter the capsular epithelium, so as possibly to render the whole capsule less permeable for the abnormal agents within the general circulation or in the neighboring tissues which upon entering the lens produce the opacifications; or else the change in the membrane may consist in its enhanced ability to exosmose certain substances out of the lens. The lack of the latter substances may result in formation of opacities.

The alpha and soft beta rays of radium act only as a general caustic, and it is a commonly accepted principle in radium therapy that unless the radium be inserted within the tumor or the abnormal tissue, the correct treatment of the abnormal conditions which do not lie directly on the surface of the skin, is that only hard filtered rays should be employed.

It is remarkable that in ophthalmology, even in the most recent publications, the methods reported still consist in the application of soft unfiltered rays. Koster (cited by A. F. Mattice, *Arch. Ophth.*, 1914, Vol. XLIII, p. 237), who treated with radium a large number of cases and a great variety of eye diseases, used a glass tube filled with radium which he placed uncovered and unprotected in any way directly upon the scleral conjunctiva. Knox, in his latest edition of Radio-Therapeutics, still recommends exposures with unscreened radium.

*Read at the Third Annual Meeting of the American Radium Society, Atlantic City, N. J., June 5, 1919.

Such methods are dangerous, since the soft unfiltered rays irritate and burn the immediately adjacent normal tissues—conjunctiva, cornea—without influencing the deeper lying abnormal tissue, the cataractous lens.

The method employed by the writer in the treatment of cataracts is similar to the technic of deep radium therapy which he is using at present in the treatment of malignant tumors and various other conditions.

A glass tube containing the radium salt or the radium emanations is placed in a brass capsule 1 mm. thick. The capsule is covered with about 2 cm. of thickness of black photographic paper and as much gauze. The whole is placed over the closed eyelid. The applications lasts two hours and the quantity of radium used equals about 25 mg. element. At the beginning of the treatment much larger quantities of radium were employed without injury to the eye, but the smaller quantities appeared to be quite as effectual. The treatments are repeated at first every week, and later at longer intervals, in accordance with the results of the ophthalmological examinations. The treatment once in two to four months should be continued for at least two years, since the cataract is a slowly developing disease.

Other operators, as well as the writer, will undoubtedly modify and improve the methods as the work goes on and in a few years the results should be checked and a definite conclusion reached as to the value of this method of treatment of incipient cataracts.

DISCUSSION

Dr. H. K. Pancoast, Philadelphia.—I would like to ask Dr. Levin if the dosage he gives causes any change in the conjunctiva.

Dr. A. S. Fleming, Minneapolis, Minn.—I am not sufficiently familiar with the pathology of cataracts to discuss the probable effect of radium on their development; but inasmuch as radium applied to immature eyes and embryos has resulted in the production of cataracts and optic nerve atrophy, I would like to ask if injury to the retina or optic nerve has been observed in these cases.

Dr. C. Everett Field, New York.—I have one case which was sent to me by a doctor who had heard of radium being used in such cases. Although this was five months ago we did not know of the technique and the doctor did not know where he had heard of it. We made two ten minutes' applications of twenty-five mg. with the lid turned back and in all the man, in five months, has had two treatments averaging six weeks apart. There has been a distinct improvement of the condition, no increase of the cataract film, and the case is perfect. My dosage is very light, and yet it was given with one-half millimeter of gold. There was no surface irritation and the man's vision is improved. He was blind in the left eye and we are working on the right eye. If there is anything of curative value in these cases it will be a splendid thing.

Dr. Isaac Levin.—Every question asked here is answered in the paper of Martin Cohen and myself referred to in my presentation. As is stated in my paper, there was no irritation or any other ill effect upon any of the other structures of the eye. I employ about 25 mgs. The glass tube is encased in one mm. of brass and the latter covered with black photographic paper and gauze to make two cm. in thickness of each. The application is continued for two hours. In the future, all workers on this subject should try either to follow closely the methods of Martin Cohen and myself, or else clearly state in their publications what variations of the method were used, so that when the results are checked up later the results may be compared.

INFLUENZA PNEUMONIA FROM A CLINICAL AND X-RAY STUDY*

By JOSEPH HARKAVY, 1st Lieut., M. C., U. S. A.,

And JOHN HUNTER SELBY, Major, M. C., U. S. A.

Chief *X*-ray Section, Walter Reed General Hospital

TAKOMA PARK, D. C.

IN the early part of September, officially September 15, 1918, the influenza epidemic, which was spreading through the country, insidiously and relentlessly, first made its appearance rather dramatically in the Observation Ward for Infectious Diseases at this Hospital. The patient, a corps man, gave a history of short onset, distinctive of an acute nasopharyngeal infection, except that it was more intense, and died two days after admission with a left-sided bronchopneumonia.

Thereafter cases appeared with great regularity, the number steadily mounting, as shown from the daily survey in Table 1, until it reached its crest on October 9, 1918. On that day, there were 650 cases of influenza in the hospital. Then came a sharp decline which continued throughout the month of November, with a secondary rise, apparently temporary in character, during the month of December, 1918.

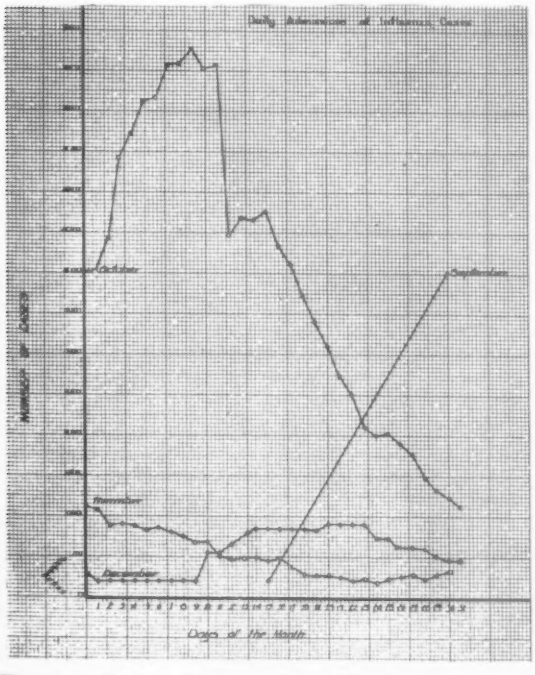

TABLE 1. DAILY ADMISSIONS OF INFLUENZA CASES.

Analyzing the number of admissions according to months, we find the following:

Admissions from	*Influenza*
September 15 to October 1, 1918	420
October 1 to November 1, 1918	1066
November 1 to December 1, 1918	85
December 1 to January 1, 1919	256
January 1 to February 1, 1919	198
February 1 to March 1, 1919	53
Total	2078

Coincident with the influenza cases, the number of pneumonias presenting themselves were thus, divided according to the admission diagnosis:

	Broncho Pneumonia	*Lobar Pneumonia*
September 15 to October 1, 1918	58	6
October 1 to November 1, 1918	199	23
November 1 to December 1, 1918	21	0
December 1 to January 1, 1919	256	2
January 1 to February 1, 1919	53	0
February 1 to March 1, 1919	2	1
Total	589	32

The mortality rate varied with the rate of admission and time of the year. Thus it is readily seen that during the height and virulence of the epidemic, the deaths entirely due to the complicating pneumonia or its sequellae were greatest in September and October, gradually diminishing in November, December and January.

The three cases admitted during February had been sick for a long while before admission; hence the high mortality.

*Read at Twentieth Annual Meeting of The American Roentgen Ray Society, Saratoga Springs, N. Y., Sept. 3–6, 1919.

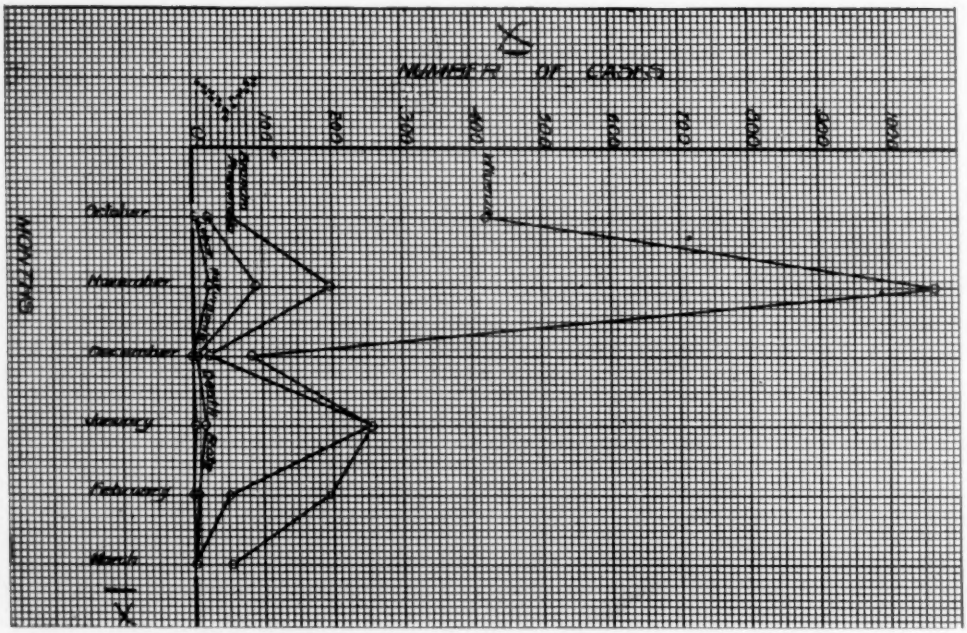

TABLE II. COMPARISON OF ADMISSIONS OF INFLUENZAS, BRONCHO AND LOBAR PNEUMONIAS, AND DEATH RATE.

	Pneumonias	*No. of Deaths*	*Percentage*
September 15 to October 1, 1918	64	22	35
October 1 to November 1, 1918	222	91	41
November 1 to December 1, 1918	21	5	24
December 1 to January 1, 1919	82	18	22
January 1 to February 1, 1919	53	9	17
February 1 to March 1, 1919	3	2	66

In the study of the epidemic as it presented itself at the Walter Reed General Hospital, it has been deemed best to analyze it from the following points of view:

1. Acute influenza and sequellae.
2. The influenzal pneumonias from a clinical and *x*-ray point of view.
3. Sequellae and complications.
4. Pathology and bacteriology.

I. INFLUENZA

In making this survey, 700 cases of uncomplicated influenza have been studied. Nearly all were in soldiers from camps in the vicinity, for which the Walter Reed is the post hospital. A fair proportion was made up of detachment men, nurses and doctors. No one was immune. Apparently the young and vigorous and those who were most active succumbed more readily and not infrequently with a greater fatality than the comparatively weak and less active.

Onset.—The period of invasion varied from one to five days, the average being two and six-tenths days. It was characterized in 20 per cent of the cases by a feeling of general malaise, pains in the lumbar region of moderate severity, and body fatigue. Various degrees of prostration and the sensation of physical inadequacy were prominent, as were also chilliness combined with a rising temperature and sweating on the least exertion. Such symptoms, however, were often not sufficiently marked to cause the vigorous soldier to go on sick report. It was only when the onset was ushered in by a severe and sudden chill, which occured in 75 per cent of the cases, when the fever frequently coming on at night was high, when it was associated with severe frontal headache, dizzines, photophobia, lacrimation and marked restlessness, that admission was sought.

The general appearance of the patient in

the early period of the epidemic was marked by extreme prostration—a prostration out of all proportion to the physical findings. He lay huddled in bed, oblivious to surroundings, face flushed—suffused with a pink cyanosis. He complained of pains, especially in the lower part of the back, varying in intensity and extent of distribution. At times, these pains were marked in the upper and lower extremities. They were referred either to the joints or bones themselves, or to the muscles, cramp-like or persistently dull in character. Initial vomiting was not infrequently observed. Continuous nausea accompanied by the sensation of a lump in the epigastrium was a notable feature in the more severely toxic, as well as in some of the milder cases. Sore throat, differing in severity, was complained of by all; difficulty in breathing and stuffiness of the nose accompanied by an irritative cough were present in 80 per cent of the cases. These initial symptoms prevailed to a greater or less degree in every patient, especially at the height of the epidemic.

Detailed analysis of the symptoms and clinical features has resulted in a classification of these cases in three groups:

1. Early severe cases, presented a temperature of onset which varied between 104° and 105° F. The fever rise was acute, reaching its climax within eighteen to twenty-four hours and, as a rule, did not persist at that figure for more than one day. During the second twenty-four hours it reached only 102°F., gradually coming down by prolonged crisis or lysis within three to four days, average 3.7 days, to sub-normal.

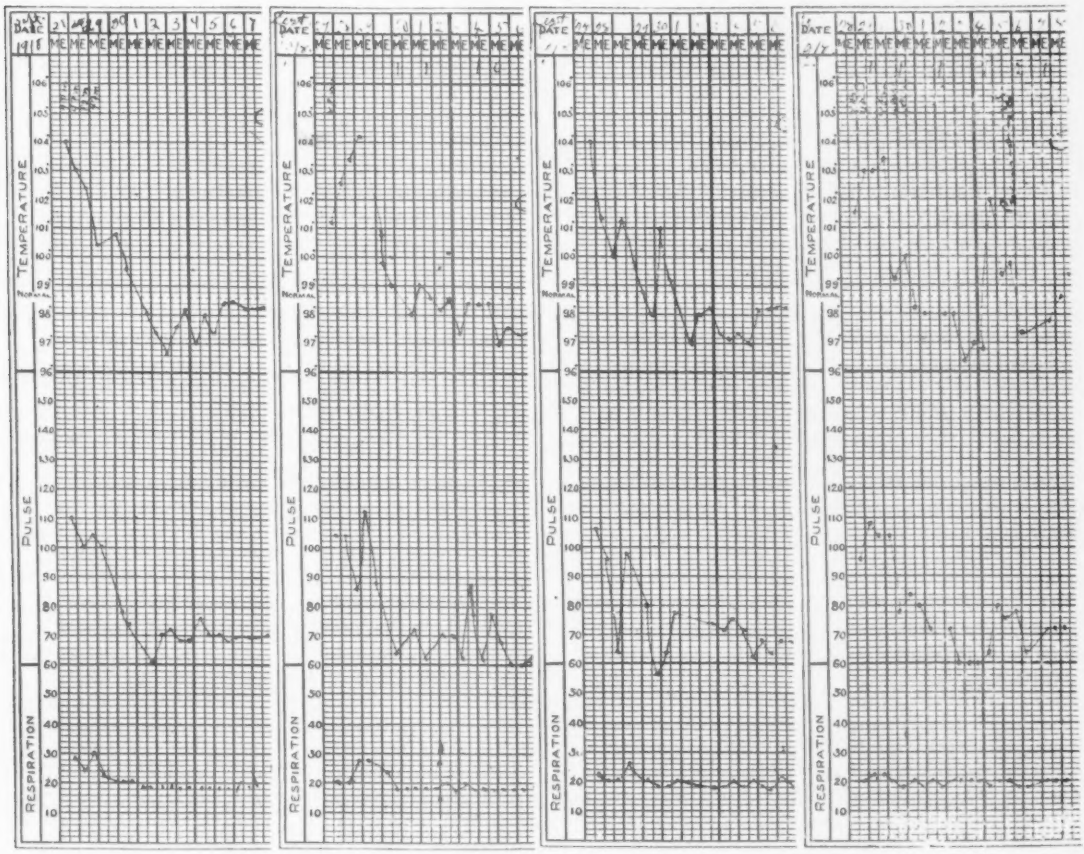

TABLE III. THE FIRST THREE CHARTS ARE TO HAVE TEMPERATURES IN UNCOMPLICATED INFLUENZAS. INFLUENZA COMPLICATED BY BRONCHO PNEUMONIA.

Among these, however, there were 10 per cent of cases especially noted during the months of December, January and February, when the virulence of the epidemic had spent itself, where the initial high fever terminated by a crisis within twenty-four hours. Correspondingly the toxemia was brief, and the prostration, although quite as severe as in the early cases, rapidly recovered from. This type of case seems to be more common in sporadic outbreaks which occur during different periods of the year.

2. The second group, moderately acute cases, ran a temperature between 100° and 102° and similarly reached its termination by prolonged crisis, or lysis, of from three to four days. Although the temperature was not so high, the toxemia was, nevertheless, not markedly lessened, and the subjective symptoms were not at all ameliorated.

3. The third group, mild types, and abortive types with temperatures between 99° and 99.5°, without acute subjective symptoms of a sudden infection, composed a most interesting class of cases. The patients gave a history of general weakness which lasted off and on for a week or more. They complained perhaps of a slight coryza, headache, or moderate pains in the back, at the end of a day's work. This was associated with some sweating during fleeting periods of stress, loss of appetite, or listlessness, and finally they could go on no longer.

On admission into the hospital, the lack of dominating symptoms created the impression that the patient was only slightly if at all ill, raising a doubt in the diagnosis of influenza. It was only after daily, careful examination of the chest that it was discovered, on about the fourth or fifth day, although there was no rise in temperature, pulse, or respiration, that pulmonary signs were present at one or another base of one of the lungs, most frequently the left. The question which of course arose in certain instances, was whether there had not been some deep focus of involvement in the lung, impossible of detection on admission until it came towards the surface, and the prostration observed, quite in contrast to the temperature, dependent on a latent preexisting pulmonary condition, undiagnosed. But of course not all of this group developed physical signs—2 per cent in all. The others gradually got better without untoward symptoms within five to seven days.

Respiratory Symptoms.—Coryza was present in 70 per cent of the cases. It should be noted that it rarely reached the exudative stage. It was distinguished rather by a tenseness of the nose and frontal sinuses associated with anosmia. Extreme dryness prevailed throughout the nasopharynx and trachea, the patient often lying with his mouth open to avoid the discomfort of breathing through a stuffy nose. The stridor accompanying respiration through inflamed nasal passages annoyingly obtruded itself during physical examination.

Inspection of the oral cavity presented distinct features. In the highly febrile cases a uniform injection prevailed throughout. The inner surface of the cheek had an intense scarlet hue; the soft palate, pillars of the fauces, uvula, tonsils, and pharynx, with its swollen adenoid tissue, were all a vivid cerise. The uvula was especially engorged and looked like a flaming baggy pendulum swinging in the hot breath. The tonsils were not swollen, nor was there ever an exudate visible. The distended interlacing blood vessels over the soft palate formed a curious blue-tinged mosaic upon a hyperemic background, and abruptly terminated at the juncture of the hard palate by a grayish line of demarcation. The entire picture impressed one as if the door of a blazing furnace had suddenly blown open.

Hoarseness was present quite frequently. In some cases it was noted on admission, but most often it developed when the patient's fever began to decline. Examination of the pharynx under such conditions was practically negative, except for some muco-pus running down in streaks. Laryngoscopy revealed congested vocal cords and, in a few instances, slight ulcerations. Dyspnea was seen only in those with high temperature.

Cough existed in the majority of patients. Somewhat suppressed, short, and jerky in

some, frequently dry and harassing in others, it was associated with a tickling in the throat and substernal sensation of tightness. This sense of constriction about the anterior or sides of the chest was found in 80 per cent of the cases. It was accompanied by a generalized bronchitis in 10 per cent of the patients. On the other hand, not infrequently a few scattered crepitating râles at the right or left base were audible, and especially at the angle of the left scapula. Such congestive signs were practically free from change of breath sounds except perhaps for slight diminution, which always set one on guard for an impending bronchopneumonia. In cases that normally reached their termination in three or four days, these would completely disappear in twenty-four hours.

The sputum in such instances was occasionally blood-tinged, but later on the epidemic was mucopurulent in nature. Hemoptysis was conspicuous by its absence in straightforward cases of influenza.

Circulatory Symptoms.—It was quite a striking fact that the pulse in this disease was entirely out of proportion to the height of the fever. The average rate in our series was 99. Common observation was that with a temperature of 103°, the pulse ran about 100 to 110.

TABLE IV: WARD 15

Temperature	*Pulse*	*Temperature*	*Pulse*
102	90	102.8	100
101	110	100	98
104	115	103.8	112
101.8	85	102	92
105	120	103	115
101.8	88	102	98
104	120	103	112

The character of the pulse was soft, tension rather low. Blood pressure, as a rule, ran on an average of systolic 105, diastolic 65, viz:

Systolic	*Diastolic*
120	70
110	60
90	55
100	60
100	65
110	70
95	60
100	60
100	65

Irregularities were rare during the disease, only five patients in all showing a trigeminal and bigeminal pulse.

The heart presented arrythmias but rarely. Cardiac outlines were normal. There was no enlargement due to dilatation, although of course pre-existing hypertrophy was not infrequently detected. The muscular quality was good, and except for an occasional systolic murmur at the base in the pulmonic area, which was not transmitted, no abnormalities except those previously present were observed.

Associated with the general low vascular tone, the vasodilation and consequent generalized widespread congestion of mucous membranes, especially of the nasorespiratory tract, epistaxis of greater or less severity occurred in 12 per cent of our early cases. It was debilitating in the extreme, especially after repeated bleeding, which was apt to occur at the height of the epidemic. Later on this phenomenon almost entirely disappeared. There were also seen, in the female patients, many instances of premature menstruation, as well as menorrhagia and metrorrhagia. All of these, with the super-imposed toxemia, were alarming to the patient. Repeated blood examination for coagulation time showed no abnormalities, eight minutes being the average.

Gastrointestinal Symptoms.—The onset with frank abdominal signs was infrequent. Nausea and vomiting, as has been mentioned, were not only confined to the periods of invasion, but lasted for two or three days with diminishing severity in the very sick. The vomiting was persistent, the patient being practically unable to keep anything down, for even water induced retching. Diarrhea and abdominal pains were observed in eight cases. The pain was diffuse, and abdominal examination revealed moderate generalized tenderness and some rigidity without definite localization. Examination of stools showed no evidence of intestinal hemorrhage.

The tongue was coated and moist in most instances, dry and beefy in others; not at all distinctive.

Nervous Symptoms.—Headache, as was

indicated, accompanying the period of invasion, described by some as boring in character, by others as feeling as if their heads were held in a vise, was present throughout the greater part of the disease, gradually subsiding with the fever. It was situated back of the eyes, and radiated to the base of the skull, in all probability due to involvement of the sphenoid sinuses. In a number (17) of the cases who subsequently came to autopsy, where it persisted even after the development of pneumonia, some of the sphenoid sinuses showed a hemorrhagic exudate, others the presence of muco-pus The frontal sinuses in these cases were comparatively rarely involved.

Insomnia, when present (and it was not infrequent), was accompanied by marked restlessness, during which the patient tossed about in bed continuously. This alternated with a somnolence that caused the invalid to be irresponsive, necessitating frequent and louder repetition of questions. Confusion of ideas was seen, but not often. Delirium and signs of meningitis unaccompanied by pulmonary manifestations, occurred in three of this series. One, on subsequent recovery, gave a history of epileptiform convulsions followed by unconsciousness, and a doubt arose as to the correct diagnosis.

Cutaneous Manifestations.— Erythema was pre-eminent; in the very sick, it was intense and universal. On pressure of the skin, it was readily blotted out, only more quickly to reappear on release of the fingers. Most evident on the face and chest, it was not infrequently tinged with a purplish hue, which invariably presaged a pulmonary complication. In the presence of marked toxemia this served as a warning sign for vigorous stimulation. In such cases quite early were noted small acne-like papules on the chest and back, especially over the sternum, which, however, may have been due to an irritation of the skin accompanying the sweats to which the patient was subject. On subsidence, a fine scaling was occasionally observed.

Sweating was indeed a common finding; 95 per cent of the cases presented this phenomenon. In many it was profuse, drenching in character; in others, though less marked, equally debilitating.

Urticaria occurred in 1 per cent of the cases, especially marked over the lower extremities, and most often seen after the temperature had come down to normal. In two cases it was followed by multiple arthritis and peri-arthritis, simulating peliosis rheumatica. The joints involved were the ankles, knees and shoulders, their appearance, with the swelling and redness, strongly suggestive of the conditions familiar in that disease. Herpes labilis was evidenced in 10 per cent of the cases.

Jaundice obtained in two patients, and the question here arose whether we were dealing was the so called intestinal form of influenza, although no abdominal features presented themselves.

Petechiae were noted in only two instances.

Eye Symptoms.—The eyes in 95 per cent of the cases presented acute, conjunctival congestion. In the very toxic, the only way one could describe them would be to say that they were cyanosed. This condition was associated with photophobia, but not often with lacrimation. Being part and parcel of the general infection, it gradually subsided with the amelioration of symptoms.

Ear Complications.—In analyzing the ear complications, it was deemed best to present the figures based on the examination of 1534 cases, some of them having pulmonary involvement, during the periods of September 17th to November 8th. Captain Howard examined most of these cases. During this period of the epidemic there were 37 ear compilcations, as follows:

Otitis,	externa,	diffuse,	unilateral	. . . . .	1
"	media,	acute, catarrhal,	unilateral	. . .	14
"	"	" "	bilateral	. . .	3
"	"	subacute suppur.	"	. . .	1
"	"	acute "	unilateral	. . .	10
"	"	" "	bilateral	. . .	5
Mastoiditis		" "	unilateral	. . .	3
	Total	. . . . .			57

Otitis externa started on the fourth day of the disease. Complications ranged from the fourth to the twenty-third day, average, ninth day. One case occurred on the third day. Nine cases of acute otitis, suppurative, unilateral, ranged from the fourth to the twenty-fifth day; one case of bilateral on the fourth day, and another on the eighteenth day.

The bacteriology of suppurative otitis media yielded the following results:

Staphylococcus albus, occurred 7 times
H. S. & Staphyl. albus occurred once.
H. S. & Friedlander, occurred once
Sterile culture occurred once.

Sinus involvement, in this last series, was not a very prominent feature. Clinically, the following types occurred:

Number of patients with sinus complications . .	6
Sinusitis, acute, catarrhal, frontal, right . . .	2
" suppur. " " bilateral . .	2
" acute " maxillary, right . .	1
Pan-sinusitis, acute, suppur.	1
Total	6

making .0033 per cent of cases.

One of the acute frontal cases started on the 18th, the other on the 24th, average, 26th day. The case of maxillary sinusitis occurred on the 4th day and pan-sinusitis on the 10th.

Tinnitus was noted occasionally. Impairment of hearing occurred in the early cases, but was associated with toxemia rather than with actual lesions in the auditory apparatus.

Genito-urinary Symptoms.—Albuminuria was present in 6 per cent of the cases and reported usually as a faint trace, or trace. Occasionally a heavy trace was encountered, but that proved to be the exception rather than the rule.

Casts were associated with albuminuria, and recorded as few hyalin or occasional granular. They were not often found, however. Leukocytes were also observed occasionally.

Hematuria was seen in two cases. No cystitis or pyelitis was observed. Frequency of urination, however, during the height of the fever obtained.

Arrested cases of gonorrhea recurred with the onset of temperature, and the usual discharge proved quite a problem in the matter of ward sanitation.

Blood Findings.—Leukopenia, reported by numerous observers, was also a striking feature in our series. In the early cases the average count varied between four and six thousand. The differential was normal in some; in many cases a relative lymphocytosis with a corresponding decrease in polynuclears predominated. Occasionally the total white count went as low as 2000. During the latter part of the epidemic, especially in the months of December, January and February, a distinct change occurred. The total count was decidedly higher, and the polynuclears on the increase. Counts varying between 15000 and 18000, with 84 to 86 per cent of polynuclear cells, were commonly seen. Concomitantly the resistance of the individual increased, while the incidence of the dread complication of pneumonia diminished.

Sequellae.—The sequellae of influenza as such are rather difficult to dissociate from those which occurred after influenza with a possible slight pulmonary complication. It is well recognized, as will be demonstrated later, that it is not always so easy to state absolutely that we are dealing with a straightforward case of influenza and nothing else. As far, however, as could be judged, we have endeavored to record the consequences following cases of influenza, uncomplicated.

In our study it has been apparent from the beginning that the nervous system had been most vulnerable and had suffered most. General weakness, persisting for from three to four weeks, in some individuals under observation from two to three months, has been particularly conspicuous. The entire constitution, as it were, had received a terrific shock. As one boy described it, he felt as if "all his pep had been knocked out of him." Many lost weight. Myasthenia on slight exertion was extremely prevalent, especially in the first two weeks of conval-

escence. General irritability, lack of ability to concentrate, mental depression, insomnia, headaches, often prevailed. Neurocirculatory asthenia, with its cold hands and feet, sensations of precordial distress, cardiac irritability, and all the variegated gamut of the neurasthenic syndrome, repeatedly presented themselves.

Probably the most interesting group of cases that have come to our observation during the epidemic have been the seventeen in whom neurological complications first manifested themselves consequent upon an attack of influenza. Most of these had a constitutional predisposition, and influenza served as a touchstone which fired dormant affections. Of these, three cases developed dementia precox of the hebephrenic type, in whom the prognosis is doubtful. Nine exhibited toxic psychosis, with its usual train of symptoms—confusion, disorientation, erotic type of delirium, hallucinations, paranoid delusions. All of these recovered within six to eight weeks. Three developed psychosis of the manic-depressive type. Two of these were manics; one depressive. Of the former, one has recovered, the other two are still under observation but improved. Two cases developed a psychoneurosis. Both of these had a typical history of constitutional psychopathy. These also are greatly improved.

The last factor which has stood out in this study, aside from the most important complications, has been the lack of immunity in some of the cases to recurrent attacks of influenza. It has been observed in twenty of this group, most of whom had two attacks within an interval of two weeks to three months during the epidemic. It was especially prevalent among those who had gotten up early, or had simply had at first an abortive or mild attack, and returned to their duties. The second attack, although mild in some, in others was much more severe and resulted in bronchopneumonia of greater or less extent.

(To be concluded in the March issue)

TREATMENT OF PRURITIS ANI BY X-RAY RADIATION

By WILLIAM J. YOUNG, M.D.

LOUISVILLE, KENTUCKY

AMONG the more troublesome local lesions, and perhaps the most intractable, pruritus ani stands in the first rank. How often are we confronted by patients suffering from pruritus ani who have run the gauntlet of all kinds of doctors and of known remedies, receiving temporary relief from each change, only to have the intolerable itching recur with added force!

From time to time there has appeared in medical literature an article with statistics describing a new method of treatment which appeared to hold out great promise; but after a trial the majority of physicians have been forced, on account of the unfavorable results obtained, to pronounce the method inefficient and in some instances to cast suspicion upon the results claimed by the originators.

In presenting this short paper I desire at the outset to save myself embarrassment by stating that there is nothing new in the treatment of pruritus ani by means of the *x*-ray. Just what effect radiation has on the lesion is unknown beyond "thinning out" the infiltrated and thickened tissues; but certainly there is amelioration of the subjective symptoms which in some cases is lasting, thus making the treatment worthy of trial in all instances.

The etiology of pruritus ani constitutes a subject about which there has existed much divergence of opinion between various members of the medical profession, and it is still safe to say that the direct cause is unknown. Pruritus ani has for years been a bone of contention between the dermatologist and the proctologist, each claiming

that it belongs to his specialty. The dermatologist speaks glibly of a neurosis, while the proctologist insists that the trouble is symptomatic of pathology higher in the rectal canal, viz.: hemorrhoids, fissures, proctitis, ulceration, polypi, stricture, cancer, foreign bodies, prolapse, cryptitis, thread worms. In some cases there is no discoverable pathology, but the majority of the patients have one or more of the foregoing complaints. As there is usually present some lesion amenable to treatment by the proctologist, it would seem to me he should be the first to examine the patient. Should he be unable to demonstrate the presence of pathology referable to his specialty, the patient could then be sent to the dermatologist. Where rectal pathology is found the proctologist is naturally the one to institute the necessary treatment, and it has been my experience that until the lesion higher in the rectal canal has been relieved, little effect of a lasting nature is produced by local treatment of the pruritus.

In the treatment of pruritus ani during the last four years I have depended entirely upon fractional doses of *x*-ray given at weekly intervals, the dosage being governed by the infiltration of the anal tissues, from four to ten radiations constituting the treatment. In the cases treated the results have varied from temporary improvement to seeming cure. My best results have been secured when working in conjunction with the proctologist, my part consisting of relieving the pruritus while he was striving to correct the particular ailment which operated as a causative factor.

The amount of radiation and the number of treatments necessary in each case may vary considerably, and must be left to the judgment of the roentgenologist. Unfiltered doses of *x*-ray being used, the one giving them should not only be well versed in estimating the dosage, but should have a definite knowledge of the appearance of the normal skin about the anal region as well as the changes produced by the effect of pruritus and also of radiation. Nothing is further from my intention than to suggest that anyone operating an *x*-ray machine is capable of successfully treating pruritus ani. It demands one skilled in *x*-ray therapy of the skin, and if the method be used correctly the results will soon be manifest. Relief from itching is usually noted after the third or fourth dose.

My experience has been that recurrence of the pruritus depends upon the amount of rectal pathology present. Where treatment by the proctologist is necessary for one year, I give the patient six to eight treatments at weekly intervals, then a rest for three months. Irrespective of the absence of pruritus I then repeat the treatment, limiting the number of doses should there have been no itching during the interval. Usually before the proctologist has finished with the patient the pruritus has entirely disappeared. The point I wish particularly to emphasize is that in the treatment of rectal lesions attended by pruritus ani, the proctologist has a consistent and valuable adjunct in the roentgenologist. With few exceptions the patients I have treated for pruritus ani have had pathology higher in the rectal canal.

CONCLUSIONS

(1) That in *x*-ray therapy we have a valuable adjunct in the treatment of pruritus ani.

(2) That where causative pathology exists higher in the rectal canal, radiation may be successfully used to control the itching.

(3) That so long as the pathology continues in the rectal canal requiring treatment by the proctologist, the pruritus ani may persist.

(4) That *x*-ray therapy in pruritus ani should be directed by a skilled operator who has definite knowledge concerning the course of the lesion and also the effect of radiation upon the tissues about the anal region.

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TWENTY-FIRST ANNUAL MEETING

The Twenty-first Annual Meeting of The American Roentgen Ray Society will be held at Rochester, Minn., and Minneapolis, Minn., September 15. 16, 17 and 18, 1920; at Rochester on the 15th, at Minneapolis on the 16th, 17th and 18th.

Further details and advance information concerning the meeting will appear in these columns from month to month.

Minneapolis headquarters, Hotel Radisson.

ORGANIZATION OF ROENTGENOLOGICAL SECTION IN THE SOUTHERN MEDICAL ASSOCIATION

In a manner highly satisfactory to those interested, the organization of a Roentgen Section of the Southern Medical Association was accomplished at the meeting in Asheville in October.

Letters suggesting the formation of such an organization were sent to a hastily prepared list of about eighty men doing *x*-ray work in the South, and although these letters were late in being mailed, twenty-two were present at the organization meeting, and letters and telegrams were received from others signifying their approval of the step and offering their support. It seemed to be the almost unanimous desire to ask that a Section on Roentgenology in the Southern Medical Association be formed, rather than that any new organization be attempted. A committee consisting of Dr. A. L. Gray of Richmond, Dr. O. H. McCandless of Kansas City and Dr. Robert H. Lafferty of Charlotte, was appointed to present the matter to the Executive Committee. The committee approved and formed the section. The following officers were appointed:

Chairman, Robert H. Lafferty, M.D., Charlottle, N. C.

Vice-Chairman, Dr. O. H. McCandless, Kansas City, Mo.

Secretary, Dr. J. W. Landham, Atlanta, Ga.

The Southern Medical Association has at present about 6,000 members drawn from the seventeen Southern States, and in this territory there are several hundred men doing *x*-ray work either exclusively or to a large degree.

The Association, in addition to organizing the Section on Roentgenology, also recog-

nised the roentgenologists in selecting as its First Vice-President one of the leading and best known Southern roentgenologists, Dr. Alfred L. Gray of Virginia.

The next meeting will be held in the fall at Louisville, Ky.

LAFFERTY.

INTER-ALLIED ROENTGENOLOGICAL CLUB

One of the outgrowths of the war was the close relations which were formed between different members of the roentgenologic services of the allied countries. About the time of the Armistice it occurred to members of the French, English and American services that these relations be perpetuated and that measures be taken to promote the good feeling and friendships which had been started. Out of this sentiment has crystallized the formation of an English roentgenologic club, whose President is Sir Archibald D. Reid, the head of the English Roentgenologic Service, and the secretary of which is Dr. Robert Knox, well known as an author. Following this movement there has been formed in America a temporary organization along the same lines, the temporary chairman of which is Dr. Preston M. Hickey of Detroit, Michigan, and the secretary, Dr. William H. Stewart of New York City. The French club, we understand, is in process of formation. The first meeting of the representatives of this international roentgenologic club will be held in the United States in the fall of 1920.

The central idea on which these organizations are being formed is largely social and in pursuance of this idea the name "club" in place of society has been selected. One of the consequences of this movement will be the furtherance of facilities for international postgraduate instruction. Postgraduate students from foreign countries will be furnished with letters of introduction from their own club, and will be given a hearty welcome upon their arrival and afforded all necessary assistance in selecting places to visit, and will be aided in the choosing of a serviceable itinerary.

It has not been the purpose of these clubs to interfere or to replace in any way the already established scientific roentgenologic bodies. The presentation of scientific programs and exhibits is already well taken care of by the various national organizations.

It is hoped that the aid which will be given to roentgenologists traveling from and to this country will repay any effort which is being made to promote good will among those of the allied countries.

P. M. H.

TRANSLATIONS & ABSTRACTS

RUSS, S., D.Sc., CHAMBERS, H., M.D., SCOTT, GLADWYS M., MOTTRAM, J. C., M.B., Experimental Studies with Small Doses of *x*-rays. (*The Lancet*, 4991, CXCVI. April 26th, 1919.)

The subject matter of the present paper consists of experimental facts as to the effects of small doses of *x*-rays upon the blood of rats and upon the susceptibility of these animals to tumor implantation (Jensen's rat sarcoma). An attempt is made to show the possible bearing of the salient features of these newly acquired facts upon the present-day treatment of malignant disease by means of *x*-rays. It will be generally admitted that in such treatment attention is usually focussed upon giving the malignant cells a lethal dose of radiation. Two suggestions are put forward here in this connection. When therapeutic doses are given to the cells of a tumor the rest of the body receives a fractional dose of the rays. It is submitted that the action of these rays, especially upon the lymphocytes in the circulation, may be deterrent to the combative forces which the patient can normally bring to bear against the tumor growth. In the second place the possibility of increasing the resisting powers of the system by means of small doses of *x*-rays is shown to have an experimental basis.

Exposure of a rat to a large dose of *x*-rays causes profound changes in its blood; the cells most affected thereby are the lymphocytes. Other blood cells are acted upon by these rays but generally to a much less extent. From the results of many experiments devised to determine the nature of the action of the *x*-ray on the lymphocytes, it has been concluded that the action is direct upon these cells in the circulation. The fact that the lymphocytes disappear from the circulation in such large numbers after an exposure of but two seconds leads us to doubt very strongly that this is due to their destruction, especially as they reappear with great rapidity. If lymphocytes "in vitro" be given a dose one thousand times as large as that required for these effects "in vivo," no degenerative changes are detectible microscopically, and no diminution in their numbers is observed.

A rat when given small doses of *x*-ray (twelve seconds) shows a 50 per cent reduction of its circulating lymphocytes one hour later; then it begins to recover, and in twenty-four to forty-eight hours is normal again. If the same dose be administered a fortnight later a similar drop occurs; the recovery is slightly delayed, but the number of lymphocytes finally reached is generally greater than at the beginning. Repeated application of such a small dose may result in a high degree of lymphocytosis.

It has been shown in previous publications that when sarcoma cells (Jensen's rat sarcoma) are inoculated into rats which have previously been immunized, the failure of the sarcoma to grow is associated with some special activity on the part of the lymphocytes. The further experimental fact acquired was that if immune rats are given a dose of *x*-ray sufficiently large to cause and maintain a marked lymphopenia, then such immune animals become once more susceptible to the growth of the sarcoma. These two experimental findings show that the lymphocytes play an important part in determining whether the sarcoma cells grow into a tumor or not. It appears that some mechanism is present in the immune animal which brings the lymphocytes to the sarcoma cells, and that this is absent in the normal animal. There is evidence that (1) rats showing extraordinarily high lymphocytes counts will bear growing tumors when inoculated, and on the other hand that (2) rats having little more than a normal lymphocyte content can exhibit all the evidences of immunity.

The *x*-rays used in the above experiments were those emitted by a Coolidge tube worked by an induction coil at a spark gap of 4 inches; no screen was used other than a thin sheet of mica covering the aperture of the tube box and a thin perforated sheet of celluloid covering the box in which the animals were placed during the *x*-ray exposures; the distance from the anode to the animal was 30 cm. The composite beam of rays would generally be characterized by the term "medium" or "medium soft."

1. The natural immunity which animals usually have towards the inoculation of spontaneous tumors can be broken down by an *x*-ray exposure sufficient to cause the disappearance of the lymphocytes.

2. The acquired immunity which results from the inoculation of blood or other cells into animals can similarly be destroyed.

3. The acquired immunity which is found in animals in which tumors have disappeared can likewise be broken down.

4. Tumor cells from a foreign species, which on inoculation will only grow with great rarity, multiply rapidly in an *x*-rayed animal until such time as the depleted lymphoid system is well advanced in regeneration.

5. Acquired immunity is destroyed only so long as lymphoid cells are reduced in number.

6. In contrast to these conditions, an immune condition can be produced instead of destroyed by suitable doses of *x*-rays. *X*-rays when administered to an animal have therefore two actions, quite apart from their direct effect upon a tumor: (a) A large dose of rays by destroying the immune condition will favor the growth of a tumor; (b) a small dose by producing the immune condition will help to control and may overcome the growth of a tumor.

The bearing of these facts upon the radiological treatment of malignant disease in man appears to us to be as follows:. Whenever a tumor is exposed to *x*-rays the lymphocytes circulating in the blood-vessels of the growth and of the surrounding tissues will be irradiated, or if the site of operation be treated the lymphocytes in the normal vessels and tissues will be similarly exposed. It is clear, therefore, that though the radiologist may be giving the primary growth the dose of radiation required for its disappearance, he may at the same time be indirectly encouraging the development of secondary growths by lowering the natural powers of resistance of the patient, especially if this comparatively large dose is repeated at fortnightly intervals, as in post-operative treatment.

It would appear profitable therefore to take all possible precautions to prevent the destruction of such cells as the lymphocytes, which, there is good reason to believe, play a defensive rôle in many varieties of malignant growth.

Finally, as regards the possibility of using *x*-rays to increase the natural powers of resistance against cancer. It must be clearly understood that up to the present it is only resistance against cancer inoculations that has been increased. Nevertheless, there is a distinct analogy between a graft introduced experimentally and a lodgment of cancer cells occurring at a distance from a primary growth. By the use of small doses of *x*-rays repeated at intervals it may be that the resistance against the development of secondary deposits can be increased in a similar way to that which occurs in the case of an experimental inoculation.

WEBSTER W. BELDEN.

GAGE, HAROLD C., CAPTAIN A. R. C. Radiographs Direct on Bromide Paper and Their Place in War Economy. (*Archives of Radiology and Electrotherapy*. No. 232, November, 1919.)

It should be understood from the beginning that the use of bromide paper to replace plates in radiography is limited. It is absolutely unsuited for fine detail and the diagnosis necessitating fine detail, such as injuries to joints, doubtful fractures, bone disease, sequestra, etc. The indications for its use which are to be considered are the two large demands made on the radiographic service which bromide paper can admirably fill, namely, the demonstration of foreign bodies and of fracture. The next demand is to verify the position of the fracture on admission to a hospital and should the patient be transferred to an apparatus for treatment by extension and suspension he will need to be radiographed in the apparatus as he lies in bed. For this work the bromide paper is ideal; sheets may be used large enough to include the articulations, with antro-posterior and lateral views on the same sheet, and in this way the results of treatment may be checked so as to give the best possible results in the alignment of the fracture. When the time comes for final results, these can be radiographed again on bromide paper so as to complete the case.

Technique—The bromide paper should be the most rapid positive paper than can be obtained (of the carbon or contrast type), and a surface about the same as that of a plate is to be preferred to an enamel surface. Intensifying screens should always be used not only on account of the reduction of the exposure, but because the print is of far better quality, being richer in detail and contrast. The tube penetration should be about 15 to 20 per cent less than the recognized penetration for plates. A tube which is too hard produces a flat and foggy print. Suitable penetration is an import-

ant factor. The exposure of course will vary with the different papers and the thickness of the part to be radiographed; it should be approximately from one-fifth to one-third of that required for a plate under the same conditions but without a screen. Development of plates with metol hydroquinone, as is usual, requires no change, for this developer works very well in developing the bromide paper. If a duplicate is required, two screens in one casette will meet the case, and little difference can be observed in the resulting radiographs. A screen may be cut in half and kept specially for the purpose; the half screens and the bromide half sheets are placed side by side in the casette, the paper lying on top of the screen on one side and the screen on top of the paper on the other. The two halves are exposed in turn, one half during each exposure being covered with lead.

The advantages of this technique are that for routine work, such as checking up on positions of fractures, etc., it is less expensive, is a permanent record to go with the patient's clinical history, cannot be broken and weighs much less than glass plates; in fact 100 sheets of bromide paper occupy less space and weigh less than 6 plates.

WEBSTER W. BELDEN.

CARMAN, R. D. The Operability of Cancer of the Stomach as Determined by The Roentgen Ray. *(J. Am. M. Assn.,* Vol. 73, No. 20, November 15, 1919.)

Without the use of the roentgen ray, a positive diagnosis of cancer of the stomach is often not made until cachexia, loss of weight, achlorhydia, obstruction, Oppler-Boas bacilli, and a palpable tumor are noted; these are all signs of advanced gastric cancer. The patient's fate depends too much on his physician's personal opinion and too little on the true but hidden conditions of the case. As many physicians have believed, and still believe, that the palpable tumor precludes operative relief, some patients whose lives might be prolonged by operation are not operated on. Others are subjected to useless exploratory laparotomies which roentgen ray examination can prevent.

The roentgenologist does not look on this method of examination as independent or ultimate, as it is only one part of a thorough clinical examination, and the verdict of operability based on its findings is only of relative value except in cases that are indisputably inoperable. The syndrome of early cases of cancer of the stomach is not sufficiently characteristic to differentiate it from that of other gastric diseases. Nor can a cellular diagnosis be made by the roentgen ray; but a filling defect may be shown which enables the roentgenologist to make a gross pathologic diagnosis in the majority of cases. An indication for operation should be recognized in the location and extent of the filling defect in the gastric contour, especially when we consider that 95 per cent of all tumors of the stomach are cancerous. As metastasis and an extended lesion prevent operation in many more cases than does the location of the primary lesion, early diagnosis seems the surest preventive of a high gastric cancer mortality; the roentgen ray has often proved to be a means of diagnosis and of forecasting the operability of carcinoma of the stomach at a time when clinical symptoms are so slight as merely to hint at malignancy.

If the roentgen ray examination reveals a tumor of the stomach, screen and plate findings should be studied with one purpose in mind—possible cure by operation. The chances for cure which the particular case possesses place it, according to the roentgen ray evidence of operability, in one of three groups: operable, border-line, or inoperable. The limits of each group are roughly marked by the roentgen divisions of the stomach: Group 1, tumors of the pars pylorica, the operable zone; Group 2, tumors of the pars media, the questionable or border-line zone, and Group 3, tumors of the pars cardiaca, the definitely inoperable zone.

OPERABLE TUMORS. GROUP 1.

In Group 1 are those tumors which are located in the pyloric end of the stomach; these are shown by the roentgen ray to be operable so far as the stomach is concerned. In this type are included those cases in which the lesion has not spread far on the stomach to the danger zone of the pars media. As approximately 70 per cent of all gastric cancers occur in the pyloric end of the stomach and as about 95 per cent of all lesions which encroach on the gastric lumen are carcinomatous, a lesion in the pyloric end should always make one strongly suspicious of malignancy. The character and size of the filling defect may also give some

hint of malignancy; but the question of malignancy which is of importance in considering the advisability of operation is of no importance from the standpoint of the possibility of operation; that depends on the amount of healthy stomach wall remaining. Often cases which present such severe symptoms clinically as to seem inoperable prove operable on roentgen ray examination, for even a large palpable tumor may be resected if it is confined to the lower half of the stomach. While a palpable tumor does not, therefore, prevent operation, it does mean that the lesion has existed for some time and that metastis may be present. Free motility of the cancerous stomach favors resectability, but signs which point to it may also be misleading. The filling defect may be atypical of cancer and the clinical symptoms alone may offer little explanation; but if the patient who has indefinite gastric symptoms has any filling defect in the contour of the stomach, whether typical or atypical of cancer, the chances are that malignant growth is present. A lesion of the stomach can be pronounced operable, however, only with respect to the stomach, as perforation and metastasis almost invariably remain undiscovered until after incision.

BORDERLINE TUMORS. GROUP 2

The tumors of the second group are those which extend so far up the stomach wall, into the questionable zone, that their resection becomes uncertain; they are classed as the border-line cases. These cases present a most puzzling problem as to operability from a roentgenologic standpoint. Their removal depends as in the cases of Group 1 on the possibility of metastasis, plus the judgment and skill of the surgeon. The position and size of the stomach may be a surgical drawback; the small high-lying stomach of the robust person offers much greater difficulty to the operator than does the relaxed stomach of the asthenic person. Therefore, if the roentgenologist is familiar with the surgeon's technic he can better form his decision as to the operability of the particular case than if he knows nothing of the operator's dexterity and willingness to attempt resection when the tumor lies in the border-line zone of the stomach.

INOPERABLE TUMORS. GROUP 3

In Group 3 are the cases of gastric tumors which are pointed with finality by the roentgen ray as inoperable. The tumors of this group are located in the cardiac end of the stomach, or they have spread from a pyloric or fundal carcinoma to within this inoperable zone. Surgery can bring no relief to the patient when the cardiac end of the stomach is cancerous. The tumors in this region of the stomach are easily recognized by the roentgen ray as inoperable.

VALUE OF THE ROENTGEN RAY

Of recent methods which have so far been adapted to discover the cancerous growth and to prophesy the chances for its removal the roentgen ray signs when correlated with clinical findings seem to be the most promising means by which operability may be increased through earlier diagnosis. So many seemingly benign lesions of the stomach prove to be malignant that the advisability of medical treatment instead of operation seems very questionable or even homicidal. Periodic roentgen ray examinations in a suspected case can, of course, be made; but if instead of retrograde changes a filling defect typical of carcinoma is noted in time, attempted operation may be too late because of metastasis.

WEBSTER W. BELDEN, M.D.

MITCHELL, WILLIAM. Splenic Calculi. (*Arch. Radiol. & Electroth.*, Lond., No. 228, July, 1919.)

In the bibliography of radiology the spleen occupies a very small place, mainly concerned with the practice of radiology in leukaemic and other conditions. In radiography it is hardly mentioned at all, except that some writers say its size can be thus determined. The writer has never seen such a condition as splenic calculus mentioned in the journals or text books, and yet most experienced radiologists must have observed them occasionally. Personally, the writer has seen from four or five clear cases *intra vitam* and on two occasions has found numerous calculi post mortem.

In the case recorded the spleen when removed showed over its antero-external surface with many snow-white plaques raised above the level of the capsule one-eighth to one-sixteenth of an inch. A skiagram made revealed numerous dense shadows, readily visible through the whole thickness of the body of a man. The author naturally considers these to be cast by the white plaques on the surface.

When they were examined no evidence of calcification or lime-salt deposit was found—the condition was due simply to thickened capsule. They, however, contained 0.9 per cent. mineral matter, consisting largely of potash salts, with minute amounts of iron and aluina. Clearly that did not account for the shadows. When examined under the fluoroscope the shadows could be clearly seen, but removal of one of the larger plaques did not interfere with the shadows, which still persisted. The shadow-producing body was removed under the fluoroscope and upon examination was found to be composed of 67.7 per cent. calcium carbonate. Of the origin and pathology the author is ignorant. Possibly they are miliary tuberculous foci which have become healed and calcified. The spleen in this case was removed from the body of a man 67 years of age otherwise quite healthy, who died of internal anthrax.

ECHLIN S. MOLYNEUX. Radium in the Treatment of Tuberculous Adenitis. *(Brit. M. J.*, London, Nov. 29, 1919.)

The therapeutic properties of radium have always been a fascinating subject, both to the medical profession and the laity, and the former has by no means reached the limits of the subject yet.

During 1913-14 the writer thought he would see what could be done by radium for tuberculous glands. As a result he is convinced that the day of radical operation will soon be past, that it will no longer be necessary to send children thus affected to the sea-side for prolonged periods, and that the unsightly scars which disfigure the necks of so many girls can now be avoided. Radium is, if properly used, a safe and—as far as one can see—a certain cure, whether for early or advanced cases of tuberculous glands. Within the period named he treated with radium between twenty and thirty cases of every grade. In every case the swellings and even old sinuses faded away. Unless there were already sinuses present, no scars were left. The skin was in some a little red for a few weeks, from the action of the radium, but this always disappeared.

In no case was any ulceration caused. It is unnecessary to describe all the initial experiments and the doses used. As a result he finds as follows:

Fifteen milligrams of radium bromide, spread out on a flat circular applicator 1¼ in. in diameter and mixed with a special varnish to keep it even and prevent loss, is sufficient for this kind of treatment. The applicator has a screen of silver 1 mm. thick and a piece of thin gutta-percha tissue tied over the whole to prevent soiling of the radium. The applicator is strapped on over the tuberculous glands. Ten hours is found to be a suitable time for each application of the above strength—that is, 150 milligram hours. The applicator is put on when the patient goes to bed and taken off in the morning. A different gland or group of glands can be attacked at each sitting till all have been covered, and the course then started again.

The patients have usually had two applications a week. Nothing was noticed for from a week to ten days, but from that time a gradual shrinkage of the glands was observed till nothing could be felt except a few fibrous nodules. He continues the treatment until all signs of trouble have disappeared. In very bad cases he usually gives in addition a few applications three months later, but doubts whether this is really necessary if the first treatment is properly carried out.

Since the writer has been demobilized from the R. A. M. C. he has had an opportunity of inspecting many of the patients he treated in 1913-14. In none of them can be found a trace of any further trouble, nor has he heard of any he has not actually seen having any signs of recurrence. Evidently,therefore, the cure is usually a lasting one. Should a case recur, he has no doubt that a further course of treatment would restore the patient to health again.